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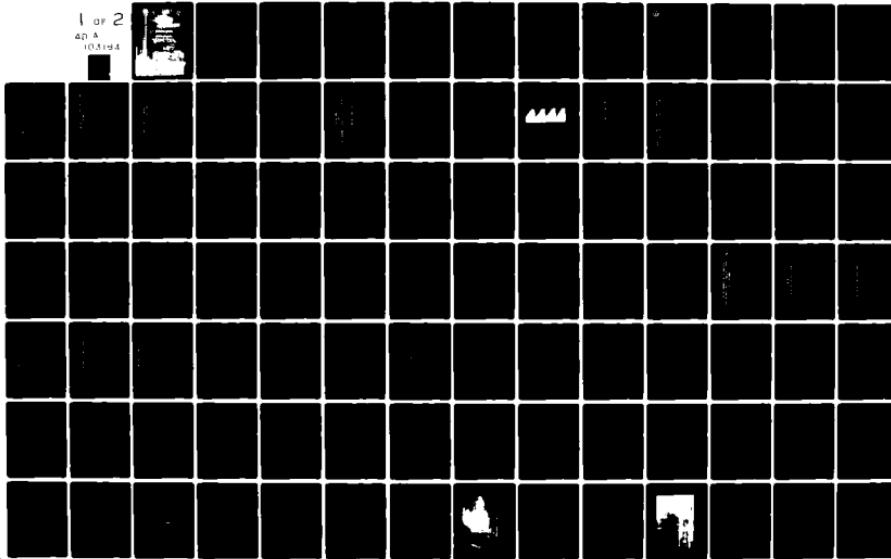
OFFICE OF NAVAL RESEARCH ARLINGTON VA
TERRESTRIAL SCIENCES SUBELEMENT REVIEW MINUTES (U)
APR 78 P C BADGLEY

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REFERENCES: Reprints from Science, Technology and the Modern Navy:
ONR Thirtieth Anniversary Volume.

Letter on file

A

INTRODUCTION

PETER C. BADLEY, 696-4120
ONR CODE 460

TERRESTRIAL SCIENCES SUBELEMENT REVIEW

April 10, 1978

Introduction and Overview

By

Peter C. Badgley
Subelement Monitor and Director
Arctic and Earth Sciences Division

The review is held in response to a request by the Chief of Naval Research and is primarily a management type review structured to follow the guidelines which he spelled out in his memo of 22 December 1977, enclosure (1). We have also tried to provide an update on the scientific progress being made by our programs and hope this will be useful to those whose interest is more concerned with the scientific aspects.

In my introduction and overview, I shall be covering a number of items as shown in enclosure (2). I shall be paying particular attention to our scientific philosophy and management strategy.

Agenda for Briefing: (Enclosure (3))

Our Research Objectives and Mission Statement are shown in enclosure (4). We support research to provide:

- An understanding of environmental factors and we support research which will lead to:
- Real time observation, interpretation and prediction of environmental factors,

both of which are essential for our operational forces.

Budget:

Enclosure (5) shows the funding situation for this subelement. Although none of these funds go automatically to any of the Navy laboratories or SYSCOMS, we do fund some tasks in Navy laboratories on a selective basis. The total amount of \$9.2 million for FY 1979 was the OSD/OMB budget submission to Congress. This Congressional budget submission was later revised to \$8.9 million as shown in enclosure (6) to allow for the Defense Science Engineering Program (DSEP). We hope to get some of this reduction back to support items which we recommend under this D.S.E.P. Program.

Enclosure (6) also shows how the funding is allocated to the individual programs of this subelement.

Funding Problem:

Dr. Johnson's review of our Arctic Program will note that in response to both scientific and strategic concerns virtually all of our Arctic research in FY 1979-81 will be focused in the eastern Arctic. The \$5.168 million shown for FY 1979 (Arctic Program) includes the resources required to support our investigations in the eastern Arctic. The Naval Arctic Research Laboratory at Barrow is poorly located geographically to support these eastern Arctic field efforts, in a cost effective manner. It is hoped, therefore, that the winding down of NARL to some reduced level will not affect, by diversion of scarce 6.1 research dollars, the vital eastern Arctic efforts.

Scope:

The scope of this subelement is shown in enclosures (7) and (8). Enclosure (7) shows the relationship of the Terrestrial Sciences subelement to other parts of the environmental sciences. You will note in enclosure (7) that we cover the air-sea-land interface region in the coastal regions and we cover the land-air-ice-sea interface zones in the Arctic. The Environmental Factors Program that Mr. Joiner will describe later involves research that relates not only to the Arctic and Coastal Environments, but also has some concerns for the air-sea interface and the ionosphere-earth wave guide. Enclosure (8) shows the major subject areas covered in the Terrestrial Sciences Subelement.

Rationale for Subelement:

The reason for this subelement is indicated in enclosure (9). Environmental factors are very important for many types of Navy and Marine Corps operations, as we all recall from the D-Day and other operations of World War II. As shown in enclosure (10), you will note that there is still:

- *A very limited knowledge of the critical environmental and geophysical factors in the eastern Arctic and Marginal Ice Areas.
- *A very limited submarine detection capability in both of these Arctic regions and in the shallow waters of the continental shelves.

In the bottom line in enclosure (9) you will note that I stress the importance of selecting the most pertinent variables to measure. Enclosure (11)

amplifies this point. In the left hand column are summarized those parameters that can have a significant impact on the success or failure of various coastal missions. The numbers in the vertical columns signify the degree of impact which these parameters will have on the success or failure of a mission if they are ignored. It is important to be able to measure and predict those parameters which are critical for particular missions. In many missions a great number of these parameters are important, and developing prediction models which will handle all of these variables is one of the major tasks of our coastal researchers.

Scientific Needs of Program:

In enclosure (9), you will note that we have a number of important scientific needs if we are to conduct this research program successfully. We must understand the major driving forces of the environment. The most important of these driving forces is the atmosphere and we must understand its relation to ice, to land and to the sea surface.

The impact of the atmosphere on coastal parameters is shown dramatically in the simple model in enclosure (12). Note that the wave patterns, coastal currents and wind directions in a coastal region are in a state of almost continuous change as a front passes through a region. In Western Europe, we have storm fronts passing across the European coasts about twice each week. If we do not understand these environmental processes and inter-relations, then it is impossible to make accurate predictions for either strategic or tactical purposes.

Technical Needs of Program:

In addition to these scientific needs, there are a number of technical needs in enclosure (13) that we must be concerned about in the environmental sciences if we are going to be able to produce research products of value to the Navy and Marine Corps.

In the basic research arena, we are concerned most with the last two items indicated, namely converting the signals measured by instruments in the field rapidly into meaningful geophysical parameters and getting this information rapidly into displays, charts or prediction models.

Key Scientific/Technology Areas:

In conducting this research program, we are concerned with several key scientific and technology areas as shown in enclosure (14). I shall say a few words about the first two of these areas, to give you some views on their current status. You will be hearing about other items in enclosure (14) from later speakers.

Remote Sensing:

An abbreviated statement of the current status of remote sensing as it relates to the Navy and Marine Corps is shown in enclosure (15). The civilian agencies are doing a great deal. It is important for us to select those areas that are most critical to the Navy. Some of the remote sensing research areas that we feel are important for our program are shown in enclosure (16).

Prediction Models:

With enclosure (12), which was presented earlier, I mentioned that it is important for us to be able to develop prediction models which can forecast the changes which occur frequently in nature.

Enclosures (17) and (18) give you several examples of the geophysical prediction models that are now being worked on by our researchers. These are tough problems and take a number of years to perfect. They are in various stages of development at this time. A major portion of our research effort in this subelement is concerned with the development and perfection of such prediction models and getting them transferred into operational use.

Management Philosophy and Strategy:

Our management philosophy and strategy are shown in enclosures (19), (20) and (21). In particular, we try to capitalize on new, exciting and innovative scientific research opportunities which could have important value to the Navy. We also continue to support a number of broad fundamental projects which can yield many end products.

Some of the new thrusts initiated in the past year are shown in enclosures (22) and (23). You will note also that we are working on several multi-national cooperative projects and the location of these and other important field projects that we have planned or are fostering are shown in enclosure (24). I should also emphasize that we are involved in collaborative research with other disciplines within ONR, NRL and other parts of the Navy as shown in enclosure (25).

Upcoming Opportunities:

Some of the opportunities we hope to exploit in the near future are shown in enclosure (26).

The North Sea Experiment, which will be described in greater detail later by Mr. Dolezalek, represents a major opportunity for ONR. It has some thirty investigator teams from eight countries. We hope to support the involvement of several key U.S. scientists in this experiment. The opportunities in the eastern Arctic are equally important.

DoD Benefits:

Some of the expected benefits we expect for the Navy and DoD over the next decade are shown in enclosure (27).



DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
ARLINGTON, VIRGINIA 22217

IN REPLY REFER TO
22 DEC 1977

From: Chief of Naval Research
To: Distribution List

Subj: ONR Internal Review of 6.1 Subelement and 6.2 Thrust Areas

Encl: (1) Review Schedule

1. The purpose of this memorandum is to schedule a series of internal reviews in support of FY 79 program decisions. The reviews will cover the individual 6.1 subelements and ONR 6.2 thrust areas. They will each be conducted during one day, as scheduled in enclosure (1), beginning on 6 February 1978.
2. The reviews will be held at NRL, commencing at 0900 on scheduled days. ONR Code 100P will be the ONR focal point for all facility and visual aid matters. Subelement monitors are requested to contact Code 100P at least a week in advance with any requests for special arrangements and with a list of attendees.
3. The reviews should strive for an atmosphere of informality, involving both speakers and audience, and hence should allow ample time for discussion. To promote such informality and to focus on issues, the participation by outside offices should be limited; although appropriate representatives from ASN(R,E&S), Op-987, NAVMAT-08, SYSCOM 03 staffs, in addition to NRL, NORDA and ONR Branch Offices, should be included. Subelement monitors will be responsible for inviting outside participation.
4. In view of the anticipated background of the audiences, the reviews should concentrate on substantive issues rather than lengthy and comprehensive project descriptions. Key questions/topics to be addressed are:
 - (a) Subelement or Thrust Area philosophy, objectives, scope and selected priority problems and issues in need of management attention.
 - (b) For each Program/Project subarea discuss:
 - (1) How does the program fit within:
 - Navy needs
 - ONR
 - Total Navy and other R&D efforts
 - (2) What are the key research and technological subareas to which the naval audience should be alert?

Enclosure (1)

Subj: ONR Internal Review of 6.1 Subelement and 6.2 Thrust Areas

(3) How does the transitioning from program accomplishment to naval utility work, what might such transitioning lead to?

(4) What are outstanding management problems or issues?

5. It is requested that Project, Subproject and Task Area documentation, e.g. 1634's, be distributed to ONR invitees one week prior to the review.

6. The ONR point of contact for further information is Dr. Robert J. Lundegard, ONR Code 102.



R. K. Geiger
Rear Admiral, USN

TERRESTRIAL/GEOPHYSICAL SCIENCES
INTRODUCTION AND OVERVIEW

- AGENDA
 - RESEARCH OBJECTIVES - MISSION STATEMENT
 - FUNDING BREAKDOWN
 - SCOPE
 - PROGRAM RATIONAL/SCIENTIFIC PHILOSOPHY
 - SCIENTIFIC NEEDS
 - TECHNICAL NEEDS
- KEY TECHNOLOGY AREAS
- OVERVIEW OF REMOTE SENSING
- EXAMPLES OF GEOPHYSICAL PREDICTION MODELS
- MANAGEMENT PHILOSOPHY AND STRATEGY
- SOME NEW THRUSTS RECENTLY INITIATED
- SOME OPPORTUNITIES TO BE EXPLOITED
- SOME EXPECTED BENEFITS FOR DOD

AGENDA
TERRESTRIAL SCIENCES SUBELEMENT REVIEW
10 APRIL 1978

0900	INTRODUCTION	P. C. Badgley (ONR 460)
0925	ARCTIC PROGRAM	G. L. Johnson (ONR 461)
1025	COFFEE BREAK	
1040	GEOGRAPHY PROGRAMS	J. S. Bailey (ONR 462)
1120	ENVIRONMENTAL FACTORS PROGRAM	R. G. Joiner (ONR 465)
1155	EARTH PHYSICS PROGRAM	R. S. Andrews (ONR 463) J. G. Heacock (ONR 463)
1225	FINAL DISCUSSION	

Approximately 25% of each time is available for discussion.

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Enclosure (3)

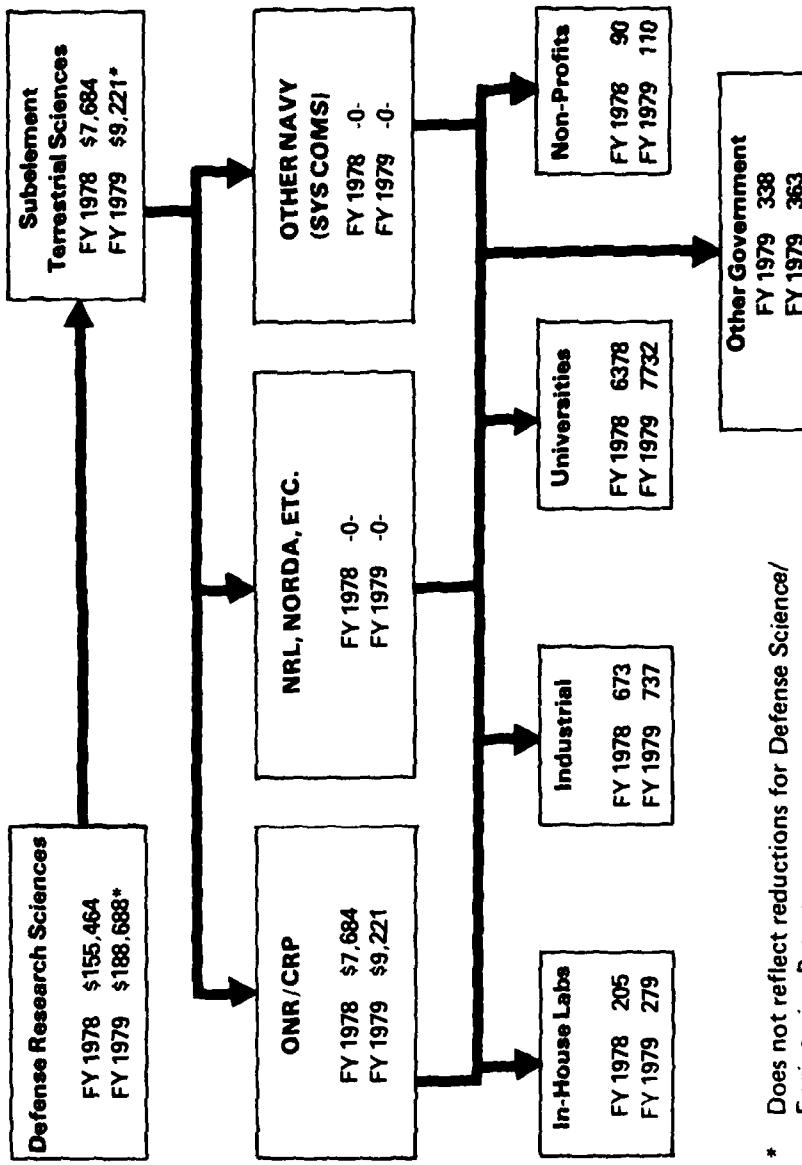
Environmental/Geophysical Factors are Extremely Important for Many Types of Navy/Marine Corps Operations

TERRESTRIAL/GEOPHYSICAL SCIENCES

Mission Statement

- **Research to Provide Understanding of Environmental Factors that Affect Naval/Marine Corps Operations and Systems – to Permit Navy to take Advantage of the Environment for Various Operational Purposes**
- **Develop Real Time Observation, Interpretation and Prediction Capabilities to Permit Operational Forces to take Advantage of Environmental Conditions, to Overcome Environmental Difficulties and to Provide More Accurate Delivery of Weapons Systems**

FY 79 OSD/OMB BUDGET SUBMISSION CODE 460



* Does not reflect reductions for Defense Science/Engineering Program

** All dollar figures are in Thousands

Enclosure (5)

TERRESTRIAL SCIENCES

(Subelement 3261153N)

		<i>FY 78</i>	<i>FY 79</i>	<i>FY 80</i>
RR 03201	Earth Physics	670	857	921
RR 03204-02	Remote Sensing	430	633	715
RR 03204-03	Coastal Dynamics	1,050	1,169	1,405
RR 02304-04	Systematic Geog.	445	584	650
RR 03205	Arctic Research	4,146	5,168	6,110
RR 03208	Envir. Factors	456	516	590
		<hr/>	<hr/>	<hr/>
		7,197*	8,927**	10,391**

* *Funding Available*

** *Congressional Budget* (Dollar Figures Are In Thousands)
As revised by the Defense Science Engineering Program

Enclosure (6)

SCOPE OF ONR PROGRAM IN TERRESTRIAL SCIENCES
AND RELATIONSHIP TO OTHER SEGMENTS
OF THE ENVIRONMENT

- **IONOSPHERE:** Includes among other things Magnetosphere, Ionosphere interactions
- **ATMOSPHERE:** Includes among other things solar effects on Atmosphere, some air-sea interactions
- **TERRESTRIAL SCIENCES:** Includes air-sea-land interface zone (*coastal zones* and continental shelves); Arctic land-air-ice-sea interactions and much of the Arctic sub-ice environment; *Crustal Geophysics* environment. Some nuclear environmental effects. Little use of oceanographic research ships.
- **OCEAN SCIENCES:** Main concentration on open ocean and deeper water areas. Heavy use of oceanographic research ships.

SCOPE

- Air-Sea-Ice Interactions, Predictions
- Ice Remote Sensing
- Physical, Chemical Oceanography (Arctic)
- Acoustics (Arctic and Coastal)
- Meteorology/Climatology (Arctic and Coastal)
- Coastal Dynamics/Coastal Oceanography
- Systematic Geography, Information Systems
- Coastal Remote Sensing (Air-Sea-Land)
- Crustal Geophysics/Passive Surveillance
- Tidal Gravimetry/Geodesy (Arctic and Coastal)
- Nuclear Environmental Effects
- Tactical Communications & Surveillance

REASONS FOR PROGRAM/SCIENTIFIC PHILOSOPHY

SCIENTIFIC NEEDS

- Must Understand *Driving Forces and Physical//Chemical Processes and Interrelations Involved:*
 - Atmospheric Circulation
 - Air-Sea Interactions and Relations
 - Air-Ice-Sea Interactions
 - Air-Sea-Land Interactions
- Must *Measure the Right Physical Properties and Right Parameters*

Enclosure (9)

EXAMPLES OF RATIONAL FOR ONGOING RESEARCH

- Very Limited Knowledge of the Vast Arctic Region and Very Limited Capability for Torpedo Delivery or for Submarine Detection in the Marginal Ice Areas
- The Capability for Forecasting Precise Environmental Conditions in Shallow Waters (Coastal Zone) is Still Very Limited due to Complexity of Rapidly Changing Conditions and Because of High Resolutions Needed for Observing Detailed Features
- The Detection of Submarines in Shallow Waters is Still Almost Impossible by Acoustic Means
- The Clandestine Detection of Mines in Shallow Waters (and Subsequent Avoidance or De-Fusing) is Extremely Difficult

OPERATIONAL SENSITIVITY (O.S.) OF NAVAL WARFARE AREAS TO ENVIRONMENTAL FACTORS (E.F.)

ENVIRONMENTAL FACTORS	SEGMENT	WARFARE AREAS										O.S. Sum's
		Strat Wrf	Surf Wrf	P/ASW**	AMP Wrf	Mine Wrf	Spec Wrf	Log Ops	Base/ Harb Sup	Air Wrf	Air Recce. & Surv	
Visibility	A,O,L/S/A	2	3	2	4	4	4	3	0	4	4	30
E. M. Prop.	A,I,EC	4	4	2	3	2	0	3	1	4	4	27
Wind	A	2	2	2	2	0	0	2	2	1	0	11
Surf. Waves	L/S/A, O	2	3	3	4	4	4	4	4	0	0	28
Currents	L/S/A, O	0	1	0	4	3	4	4	3	0	0	19
Tides	L/S/A	0	0	0	4	4	3	4	3	0	0	18
Ice, Icing	L/S/A, S/A	4	3	4	4	3	2	3	2	0	2	27
Trafficability	L/S/A	0	0	0	4	0	0	4	1	0	0	9
Bathymetry	L/S/A,O	2	2	2	4	3	2	4	3	0	0	22
Sound Prop.	O	3	2	4	2	2	0	2	0	3	4	22
Int. Waves	O	3	0	4	0	1	0	0	0	0	0	8
Layer Depth	O	3	2	4	0	0	0	0	0	0	0	9
Magnetics	E.C.	3	0	3	0	3	0	0	1	0	3	13
Gravity	E.C.	3	0	1	0	1	0	0	0	0	0	5
Elec.Hazards	A, S/A	4	3	0	2	0	0	2	1	3	3	18
Env. Catastrophes*	A,SA,LSA,EC	0	4	0	4	4	4	4	4	1	1	26
TOTALS		35	29	31	41	34	23	39	25	16	21	

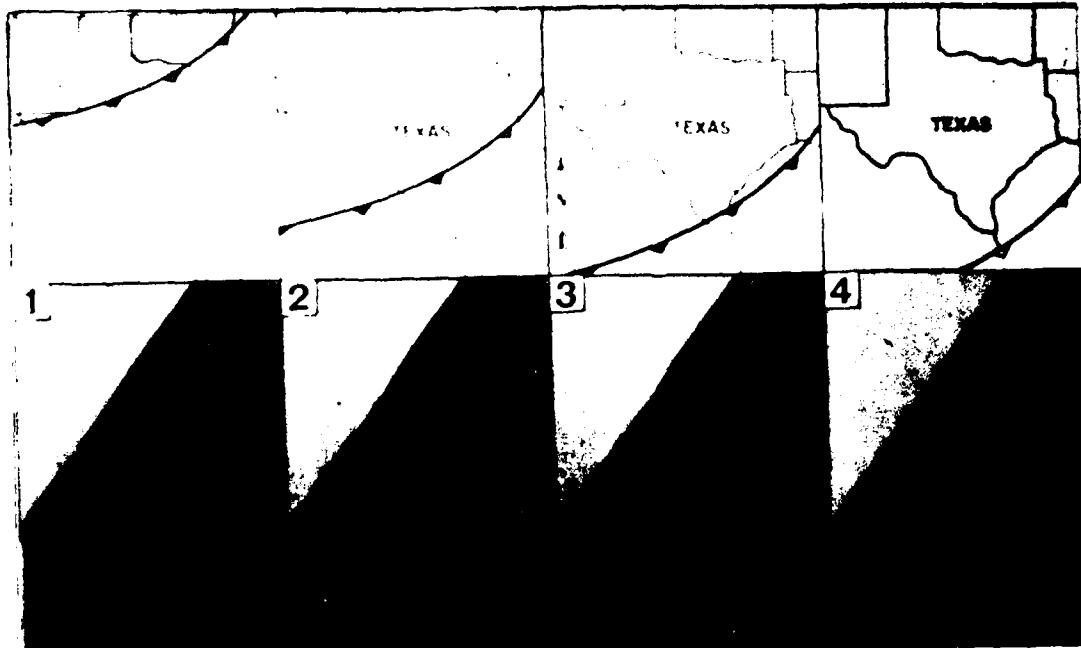
I = Ionosphere, A = Atmosphere, L/S/A = Land/Sea/Air Interface, S/A = Sea/Air Interface, O = Ocean, EC = Earth's Coast

1, 2, 3, 4 = Little, Minor, Moderate, Major influences on operations if ignored

* Environmental Catastrophes includes hurricanes, Tsunamis, Earthquakes of infrequent but severe nature

** Includes Shallow Water Submarine Warfare

This figure shows why the environment is so important for Marine Corps operations. Environmental factors are listed in the left hand column and the numbers 1, 2, 3, 4 represent increasing degrees of influence which the environment factors exert upon the various warfare areas. For example, if we were to ignore longshore currents in an amphibious operation, this could cause a major detrimental influence upon the success of such an operation.



$B_p \uparrow$ BAROMETRIC PRESSURE \rightarrow WIND mph \swarrow BREAKER ANGLE \blacktriangleleft CURRENT

Changes in Waves, Wind, Currents, etc. Resulting from Passage of
Storm Front Through a Coastal Area

The ultimate objective of ONR's various Remote Sensing Programs vis-a-vis inshore warfare activities is to be able to provide near real time observations or up-to-date tactical predictions of such coastal environmental factors as longshore currents, wind and breaker direction and intensity, visibility, etc. In this example we note that these factors are in a state of almost continuous change with the passage of a major frontal system through a coastal region. One of ONR's major objectives is to develop a capability to monitor and predict in real time, changes in coastal conditions throughout the world from a few strategically located positions.

RELATED TECHNICAL NEEDS

Must be able to measure/sense phenomena:

- With high precision and resolution
- Under all weather conditions
- Repetitively (to detect changes)
- In remote areas of the world

To be of value militarily must be able to:

- Process and interpret data rapidly
- Input information rapidly to prediction models and displays

Enclosure (13)

KEY TECHNOLOGIES IMPORTANT FOR THE EARTH/TERRESTRIAL SCIENCES

- Remote Sensing
- Geophysical Prediction Models
(Numerical, Experimental)
- Signal and Image Processing and Displays
- Information Systems
- Calibrated Field Sites – Test Ranges

BRIEF OVERVIEW OF CURRENT STATUS OF REMOTE SENSING

Civilian Agencies are Pushing Ahead Vigorously on New Spacecraft Systems and are Producing some Instruments and some Data of Significant Value to the Navy/Marine Corps.

- *Navy/Marine Corps Should Concentrate on:*

- Acquiring Instrumentation with Proper Wavelengths and Bandwidths for Recording Air, Sea, Ice and Land Information of Value for Navy/Marine Corps
- All Weather, Water and Ice Penetrating Sensors and Their Data Products
- Rapid Transfer and Management of Data and Display of Key Information
- Achieving Adequate Resolution when needed Using Aircraft to Supplement Satellite and OTH Systems

ENCLOSURE (15)

BRIEF OVERVIEW OF CURRENT STATUS OF REMOTE SENSING
(continued)

● *Remote Sensing Problem Areas Needing ONR Support*

- Interpretation of Radar Signals from Accelerating or Decelerating Waves Surfaces
- Overcoming Atmospheric Radiation and Attenuation, Water and Ice Penetration Problems
- Multiple Frequency Analysis and Signal Enhancement of Environmental Phenomena of Unique Importance to Navy/DOD
- Optimum Use of Remotely Sensed Data from Various Sources (Civilian and DOD) in Environmental Prediction Models Important to Navy/Marine Corps

ENCLOSURE (16)

SOME EXAMPLES OF GEOPHYSICAL PREDICTION
MODELS BEING DEVELOPED

- Time of Arrival of Waves from Distant Storms, and Transformation of Wave Spectra from Deep Water to Shallow Water, Knowing Position of Storm Center and Knowing Shallow Water Bathymetry.
- Prediction of Current Direction and Speed as a Function of Depth, Knowing Shallow Water Bathymetry and Deep Water Wave Spectra.
- Transformation of Deep Water Tidal Forces (Acquired by Sea Floor Gravimeters) Across Continental Shelves to Coast Lines so as to Yield Coastal Tide Heights and Times, Knowing Shallow Water Bathymetry and Frictional Factors.
- Prediction of Arctic Ocean Ambient Noise Levels, Knowing Atmospheric Pressure Gradients, Noise Frequency, Time of Year and Geographic Location.

SOME EXAMPLES OF GEOPHYSICAL PREDICTION
MODELS BEING DEVELOPED (cont'd)

- Prediction of Ice Distribution and Thickness as a Result of Inputs of Air and Water Forcing Functions, Coriolis Force and Internal Friction.
- Transformation of Energetic Particle Measurements at Satellite Altitude into Ionospheric Parameters to Allow Radio Propagation Prediction Under Disturbed Ionospheric Conditions.
- Prediction of Location and Yield of Underwater Nuclear Bursts Through the Use of an Acoustic Reverberation Analysis Model (Single Detector Location).
- Knowing the Signal Characteristics (Signal Strength, Wave Spectra, Timing, etc.) from a Source of Seismic Energy (Artillery, Submarines, etc.) and Knowing Something About the General Subsurface Geological Conditions, the Model Will Predict Appropriate Energy Transfer Functions Which can then be Used in Data Processing Algorithms for Target Location.

MANAGEMENT PHILOSOPHY AND STRATEGY

- Close Contact with Scientific Community on a Peer Basis, to Assure that Good Research Opportunities are Recognized and Funded (e.g. Annual Conferences of Coastal Researchers)
- Maintain Close Liaison with Naval/Marine Corps and Other DoD Users, to Better Understand their Needs, to Develop Optimum Programs, and to Assure Technology Transfer (e.g. Arctic 5-Year Plan)
- Extensive Use of Workshops Involving Both Scientific Experts and Naval/Marine Corps and Other DoD Users, to Identify Optimum Programs (e.g. ONR/Marine Corps Passive Surveillance Conference)

MANAGEMENT PHILOSOPHY AND STRATEGY

- Close Cooperation with Other Federal Agencies and with Other Countries to Assure Cooperative Use of Expensive Resources, and to Assure Comprehensive Experiments (e.g. *FRAM I*, *North Sea*, *Norwegian Projects*)
- Conduct Research in Geographic Areas Having Strategic Importance (*E. Arctic, Europe, Middle East*)
- Emphasize Areas Where Strong Expanding Navy Need Exists and Where Division has Unique Ability to Contribute (e.g. *Remote Sensing*)
- Concentration in Areas Where SYSCOMS and Operators have Ability and Enthusiasm to Follow Up (e.g. *Passive Surveillance*)

MANAGEMENT PHILOSOPHY AND STRATEGY

- Technically Feasible with Limited ONR Resources and/or Availability of Other Agencies and Countries to Share in Funding (e.g. Shallow Water ASW (NORWAY, etc.), NATO Cooperation)
- Capitalize on New, Unique and Important Research Opportunities (e.g. Availability of SEASAT A and NIMBUS G)
- Maintain Support for Broad Fundamental Programs Which can Yield Many End Products (e.g. Fundamental Studies of Coastal Processes, Geophysics/Acoustics Signal Processing)

SOME OF THE NEW THRUSTS INITIATED IN PAST YEAR

● REMOTE SENSING

- Interaction of *synthetic aperture radar* energy with water waves and Arctic Ice
- Atmospheric factors affecting IR sensing at earth's surface
- *Raman spectroscopy* for subsurface temperatures and salinities
- Dual antenna air borne pulsed radar for *ice thickness profiles*
- Integration of *satellite altimetry* and sea surface height (tide) data for *improved missile accuracy* and *coastal tide predictions*

SOME OF THE NEW THRUSTS INITIATED IN PAST YEAR
(continued)

● MULTI-NATIONAL COOPERATION

- Planning for *East Greenland current project* (land/air/ice dynamics study), with Denmark, Canada, U. K., etc.
- Ice forecasting, remote sensing, and acoustics in Arctic (*Sovereign* and *NORD* exercises, etc.) with U. K., Denmark, Canada
- Fjord project in *Svalbard* in cooperation with Norway
- Scientific study of European coasts and Arctic with various European groups
- Coastal projects with Turkey, Oman, Egypt, Nicaragua

ENCLOSURE (23)

LOCATION OF SOME ARCTIC
AND EARTH SCIENCES FIELD ACTIVITIES

PF CC NS
S MI
L
O C E A S
A R C T I C

C

**SOME EXAMPLES OF CLOSE COLLABORATION WITH
OTHER SCIENTIFIC DISCIPLINES**

- Between Coastal Hydrodynamics (Code 462), Fluid Dynamics (Code 438) and Physical Oceanography (Code 481)
- Between Code 460 (Remote Sensing Activities) and Codes 481, 102-OS, and 421
- Between Earth Physics Signature Analysis (Code 463), Inversion Analysis, Codes 436 and 432, Marine Geology (Code 483), Non-acoustics ASW Effort (Code 222), and Arctic Geophysics (Code 461)
- Between our Nuclear Effects and Communication Research Efforts (Code 465) and Related Research Efforts in Codes 222 (Sensor Systems) and Code 427 (Electronics)
- Between Arctic Research and Physical Oceanography Efforts of Code 481 and Acoustics Efforts of Codes 222 and 486
- Air-Sea Interaction Between Codes 462 (Coastal), 465 (Atmospheric) and 481 (Physical Oceanography)

SOME OPPORTUNITIES TO BE EXPLOITED IN NEAR FUTURE

• REMOTE SENSING

- ONR involvement in major North Sea experiment.
- Satellite receive/readout facilities for major ONR researchers.
- Push for higher resolution and zoom capabilities on upcoming satellites.
- Expand data collection capabilities of HF tracked coastal drogues.

• EASTERN ARCTIC OPPORTUNITIES

- Exploit all available research platforms and cooperative mechanisms to obtain data from little known segments of Eastern Arctic (e.g., East Greenland Drift, Norwegian and Svalbard projects). Need upgraded Logistic support capabilities.

• CRUSTAL GEOPHYSICS

- Need field tests with 3-component geophone arrays for detection of submarine (shallow water), artillery and other weapons systems.

SOME OF THE EXPECTED BENEFITS FOR DOD

TIME TO ACHIEVE OPERATIONAL CAPABILITY*

COASTAL

1982 - 87

- Real time capability for observation, prediction and display of coastal environment conditions for amphibious and mine warfare operations and shallow water ASW - on world wide basis

COASTAL/ARCTIC GEOPHYSICS, ACOUSTICS

1982 - 84

- Hostile weapons location (submarines, artillery, minefields, etc.)

1982 - 84

- World wide prediction of tides and geoid for improved missile accuracy, amphibious operations, submarine navigation

1982 - 87

- Arctic submarine detection. Improved under ice navigation and delivery of torpedoes and missiles, improved ice forecasting

DESIGN CRITERIA

- For future naval systems to permit effective operation and survival under various environmental conditions (natural and manmade)

* Assumes continued 6.2, 6.3, etc. follow-on

ARCTIC PROGRAM

R.K. McGREGOR, 696-4720
ONR CODE 461

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I. INTRODUCTION

The prime objective of the Arctic Program is to stimulate and manage a research program that keeps pace with operational needs and known technology gaps.

Research is, therefore, required to acquire the environmental information that is essential for optimizing submarine/antisubmarine detection and interdiction techniques in the Arctic Ocean and its approaches from the Atlantic and Pacific Oceans. Additional objectives are to improve ice forecasting and climatologic predictions, long range communications, and the efficiency of potential Arctic amphibious, air, and surface operations, Arctic construction, and human adaptability to the Arctic environment.

Strategic Importance

During the 1950s and 1960s the principal justification for support of ONR's research and development in the Arctic Ocean was its possible significance as a frontier with Russia and as a scene of military operation (over-the-pole manned bomber threat). The growth of the USSR icebreaker fleet and the recent Soviet demonstrated capability to launch ICBMs from submarine platforms in the Arctic lends renewed significance to these earlier fears. Additionally, the freedom of access to the Arctic Ocean from the Atlantic Ocean is being challenged by the Soviets as well as the right of innocent passage.

Recent economic developments have added another reason for the strategic importance of the Arctic. Its potential as a waterway to support exploitation of petroleum and as an area of off-shore petroleum production has drastically changed its importance and the requirements for protecting U.S. presence there. Long-term Navy-supported geophysical studies indicate that the U.S. Alaskan North Slope, and offshore continental shelf probably contain substantial petroleum reserves. These developments pose strategic considerations of increased concern to the Navy in its function of protecting U.S. interests and property in this area.

Tactical Importance

In regard to Naval tactics the Arctic Basin is unique -- millions of square miles of tumbled ice, churned constantly by the wind, with new open leads and new pressure ridges in a constant state of flux. Compared with other regions, weather conditions, although varying between wide seasonal extremes, are remarkably uniform and predictable over vast areas.

To the fleet, these operating conditions demand drastic revision of normal procedures. The tumbled pressure ridges crisscross the surface and impede travel on and under the pack ice, but they also provide concealment from prying radar and sonar. Every natural environmental factor,

from the unpredictable ionosphere to the uncharted rugged floor of the Arctic Sea, suggests possible advantages as well as handicaps.

The Arctic Program is atypical in ONR since it is an area program and involves many disciplines (atmospheric physics, sea ice physics, geography, coastal hydrodynamics, acoustics, cold region adaptation and construction problems, etc.). The area involved is that region north of the Arctic Circle and the Marginal Ice Zone (MIZ) which is the area immediately adjacent and contiguous to the Arctic Ocean which has an annual ice cover. The boundary between these two areas is imperceptible and not fixed in time and space. The Arctic Basin, as defined, is about five million square kilometers in area. The Seas: Kara, Laptev, New Siberia, Chukchi as well as parts of Bering, Barents, Labrador, Norwegian, and Greenland Seas, parts of Davis and Denmark Straits, the straits, bays and gulfs of the Canadian Archipelago, part of the Gulf of St. Lawrence, Baltic Sea, and the northern end of the Sea of Japan. It is our purpose to understand, predict and ultimately make an effort to control this environment for our use.

II. PRINCIPAL THRUSTS

1. Determine various Arctic/Marginal Ice Zone Arctic Environmental parameters (biologic productivity, sediments, coastal processes, sea ice, water masses and currents, air-ice-sea interactions) for potential effect upon weapon systems and ASW/USW operation.
2. Crustal Geophysical/Geodesy. Determine Arctic potential field and the controlling crustal processes for use in ASW/Vertical Deflection and surveillance purposes.
3. Determine the Acoustic characteristics of the Arctic in support of naval operations.
4. Investigate the potential for Remote Sensing in support of environmental forecasting, ASW/USW in Arctic areas.
5. Environmental Models. Develop prediction capabilities for major water and ice movements, ice growth and decay, climatology, etc., under influence of various atmospheric and oceanographic stresses for use in supporting fleet operations.

Program Components

Description: Empirical studies are a necessary first step for the determination of the effects of the Arctic environment of naval operations. Due to the remoteness and harsh climate, knowledge of many aspects of the environment such as the dynamics of the upper water masses, is still in

a rudimentary stage. For example, the distribution of ice thickness is almost totally unknown.

Prediction: Once a sufficient data base is acquired, models can be constructed and a predictive capability will become a reality. Crude ice distribution and thickness models have been constructed. Urgently required are models of the upper layers of the Arctic water mass for the submarine fleet and weapon systems.

Control: Control or utilization of the environment is the ultimate goal of the program. At the present time, we are well removed from this goal.

Funding

A summary of the funding of the principal thrusts of the Arctic Program is shown in Figure 1 by total percent effort and funding trends from FY 77 through FY 79 in thousands of dollars. Emphasis is shifting toward modeling efforts, acoustics, and remote sensing. Due to probable wind down of NARL activities, logistic support has been integrated in the thrust budgets for FY 79 under the assumption that support will come from various contractors. Figure 2 shows the breakdown of the allocation of CRP funds to various research organizations.

III. DESCRIPTION OF MAJOR PROGRAM THRUSTS

EFFECTS OF ARCTIC ENVIRONMENT

The objective of this thrust is to develop capabilities to identify those environmental factors that can support or degrade Navy operations in ice-covered waters whether they be nearshore, surface, subsurface, or air. We must know the effects of various Arctic and MIZ parameters upon active and passive surveillance systems, upon submarine navigation, target acquisition, weapons guidance, and communications. We must understand the nature and distribution of ice movement, of ice roughness, of thermal cracks, of ice deformation features, of biologic populations, coastal processes, and marine sediments. Significant scientific problems are: (1) distribution, origin, and composition of Arctic aerosols; (2) cryosphere paleoclimatology; (3) dynamics of Arctic mixed layer; (4) coastal and water mass dynamics of fjords, and (5) topside/bottomside ice relationships.

Climatology and Meteorology

(A) Objectives:

Determine the effect on the Arctic and global climate of various environmental parameters in the Arctic region. This is a diverse effort covering paleoclimatology from sediment cores, CO_2 exchange rates between

ice and the atmosphere, heat fluxes from the ocean and ice, stratus clouds and the Arctic haze layers. Much remains to be learned about the vertical and horizontal heat fluxes, regional and mesoscale air-sea transport of gases, and the effect of gases on other physical, chemical, and biological systems in the sea. These facets of the environment all affect the ice cover which is of paramount importance to Arctic operations. The polar regions provide a unique phenomena by the presence of sea ice which traps gases. Gas composition and transport within the sea ice may be highly time dependent and effected by changes in air temperature, pressure, biological productivity, and partial pressure of gases dissolved in the sea.

Physical Oceanography

(A) Objectives:

This program is focused toward direct current measurements and water mass analyses to elucidate the vertical and horizontal fluxes and energy through the Arctic Ocean. Of prime importance is a complete understanding of those processes in the Arctic mixed layer which determine the density and velocity structure of the upper 300 m. Varying environmental conditions such as open leads, formation of new ice, pressure ridges, and storms all effect the underlying water masses and fluxes of mass and energy.

Ice Physical Properties

(A) Objectives:

The objective is to determine mechanisms of thrust faulting in sea ice, modes of formation of pressure ridges and quantify frictional drag; to determine loading and freezing characteristics of sea ice for runway construction; and quantify ice thickness distribution and relation between surface and bottom roughness.

Geologic Processes

(A) Objectives:

This field of research covers a wide field of investigations ranging from permafrost to deep water sediment types. Arctic coastal studies are directed toward engineering properties and dynamic processes of sedimentation on the Alaskan continental shelf. Drillings on the Alaskan shelf have been completed to determine the extent and physical characteristics of marine permafrost. Arctic Basin sediments are being studied for physical properties. A chart of sediment types of the Arctic Basin has been constructed for use by the acousticians.

CRUSTAL GEOPHYSICS/GEODESY

(A) Objectives:

The objective of this research field is to gain an improved understanding of the variations in gravity and magnetic potential fields in the Arctic. This thrust is directed toward defining the location of major gravity, magnetic and bathymetric anomalies, determining the relationship between the potential field variations and the geological structure of the Arctic Ocean floor, applying the knowledge gained to the prediction of trends and amplitudes of these anomalies in unsurveyed areas. The significant scientific problem is origin, structure and history of the Arctic Basin and predictability of bathymetry and gravity and bathymetry from aeromagnetics.

ACOUSTICS

(A) Objectives:

This thrust is directed toward determination of the acoustic signature of the Arctic. Most other Arctic scientific elements such as understanding of ocean/ice dynamics, ocean floor characteristics and ambient noise distribution are limiting environmental factors to the Arctic acoustic signature, and, therefore significant contributors to the acoustic program. For example, the design of surveillance equipment requires knowledge of the properties of propagation and the ambient noise field. Development of useful models for acoustic prediction requires not only acoustic data but also environmental data of the underwater medium and its boundaries. Investigators are using existing acoustic and environmental data to improve and develop acoustic models for quantitatively understanding and predicting characteristics of propagation and ambient noise. Significant scientific problems are the effect of the Arctic environment (bottom, water structure, ice) on the acoustic signal, and signal coherence both temporally and spatially.

REMOTE SENSING

(A) Objectives:

The objective of this program is to utilize remote sensing to monitor natural ice and ice phenomena in the Arctic to obtain ice signatures, determine ice characteristics and dynamics to permit mathematical modeling of the ice which will lead to ice and weather forecasting capabilities.

Remote sensing in the Arctic is still in the stage of requiring ground truth measurements to relate the natural phenomena to the received imagery. Needed is the capability to collect the following information by either aircraft or satellite in flight:

(1) Sequential imagery which can be used in conjunction with other available information to define ice drift and deformation. (Pressure ridges, rafting, size and location of leads, polynas).

(2) Direct measurement of ice thickness.

(3) Direct determination of ice types and the physical state of each type. (Concentration, age, electrical properties).

(4) Top and bottom roughness of the ice pack.

The significant scientific problem is the relation between the remote sensing signature and ice physical characteristics.

ENVIRONMENTAL MODELS

(A) Objectives:

The objective of this major thrust is to develop predictive models of ice distribution, growth, decay, thickness and wave damping as a function of air temperature as dictated by the dynamic Arctic environment and how the ice growth, heat balance and salt rejection are influenced by the thickness of the ice and the state of the surface. The near-term goal of this program is to develop a complete thermodynamic-dynamic sea ice model which has adequate coupling to the atmosphere and ocean to allow detailed simulation and prediction studies to be carried out. Acoustic models are covered under the acoustic section.

IV. RELATIONSHIP TO OTHER PROGRAMS

(A) Interface Within ONR

It is considered vital to the program to utilize the in-house expertise within ONR in management of the CRP program. Figure 3 illustrates the active interface within ONR.

(B) Navy Laboratories

Figure 4 delineates active program interaction with Navy laboratories. Programmatically, it is considered of great value to interact with Naval centers of excellence to ensure a relevant, dynamic program.

(C) Interagency

Where possible, active interaction with the operational Navy is carried out. Figure 5 lists the most prominent areas of active interface. Additionally, research programs are interfaced on a classified level with Arctic submarine ice exercises.

(D) International

Interface with both DoD and in the interagency arena is outlined in Figure 6, and on the international front in Figure 7.

V. PROGRAM RELEVANCY

Figure 8 outlines those areas in which program thrusts and sub-thrusts are addressing Naval operational requirements as stated in the Five-Year Arctic Planning Guide.

VI. TECHNOLOGY TRANSFER

A research program does not serve its ultimate purpose unless the great volume of collected basic research knowledge is transferred in a useable form to the operators.

One mechanism for this transfer was the establishment of a Chair in Arctic Marine Science at the Naval Postgraduate School in Monterey. The purpose of this Chair is to: (1) conduct research into problems in the Arctic that are of interest to the Navy, (2) translate the growing basic research results into operational Navy products, (3) foster an interest in the Arctic among naval officers, (4) to "spotlight" the Navy's growing interest in the Arctic.

There are numerous research problems having Navy application that this Chair is addressing. The prime area of transfer at this time is that body of data resulting from the Arctic Ice Dynamics Joint Experiment (AIDJEX). The Chair presently has a student translating the AIDJEX model into the Naval Environmental Prediction System through NEPRF and FNWC. Figure 9 outlines the major technology transfer presently occurring.

VII. AREAS OF SPECIAL INTEREST

The eastern Arctic is of especial interest to the program for the following reasons:

- (1) The area is largely unknown to western scientists;
- (2) There is no data available to western scientists on the structure and dynamics of the Transpolar Current since Nansen's work in 1893-96;
- (3) Geophysical data are required to validate aeromagnetics;
- (4) Acoustic propagation, ambient noise and reverberation are unknown.

To address this problem, a number of field exercises are being planned.

(A) Marginal Ice Zone (MIZ)

- Location: At the edge of the marginal ice zone seaward of Mestersvig, East Greenland (See Figure 10).
- Time Frame: June - August 1978
- Investigators:
 - Dr. Peter Wadhams, Scott Polar Institute Cambridge, England
 - Dr. Preben Gudmandsen, Technical University, Lyngby, Denmark
 - Dr. Warren Denner, Naval Postgraduate School, Monterey

• Approach: Establish a 3 man ice camp in the marginal ice zone with concurrent remote sensing overflights. Support will be from Mestersvig.

• Scientific Objectives: The Marginal Ice Zone in the East Greenland Current consists of discrete floes with a mean diameter that increases with distance from the ice edge. A major factor which creates and maintains the distribution of floe sizes is wave action. Waves and swell from storms in the North Atlantic and Greenland Sea impinge on the ice margin where they cause large floes to break up by bending failure and by collisions. At the same time, large floes are advected into the marginal ice zone from deeper regions of the pack by the action of wind or eddies along the edge of the East Greenland Current. A dynamic equilibrium may be set up between floe fracture and the arrival of fresh large floes. Since each floe acts as a scattering centre which partially reflects incoming wave energy, the floe size distribution determines the penetration of wave energy, and hence, the rate of break-up. Similarly, the balance between break-up and floe advection determines the floe size distribution, so that any equilibrium which occurs is governed by feedback mechanisms. This activity is confined to a "skin depth" close to the ice edge, of the order of tens of km wide.

This field investigation will be directed toward determining:

- (a) The decay rate of a wave of a given period due to scattering by floes of a given geometry;
- (b) The criterion for the failure in bending of a floe of given diameter and thickness due to the action of a wave of given period;
- (c) The ambient noise levels;
- (d) Serve as ground truth for Danish remote sensing overflights of the sea ice.

(B) LOREX

- Location: 1000 km north of Alert on the Lomonosov Ridge. See Figure 10.
- Time Frame: The proposed drift would take place during the spring of 1979 and would last for two months.
- Investigators: This is a Canadian experiment which the U.S. has been invited to participate in. The senior scientist is Dr. J. F. Sweeney, Earth Physics Branch, Energy, Mines and Resources. U.S. participant will be Dr. H. Kutschale of Lamont-Doherty Geological Observatory.
- Approach: Establish 3 ice camps in the vicinity of the North Pole and thence drift across the Lomonosov Ridge. The U.S. FRAM I station is a proposed complementary effort. Canadian logistic support will be from Alert.
- Scientific Objectives: Continue and expand a systematic study of Lomonosov Ridge. Early studies concentrated on establishing a line of gravity stations from Alert to the Pole. This effort will include other geophysical parameters such as seismic, geomagnetic and heat flow measurements in the on-going investigations. Dr. H. Kutschale will conduct acoustic propagation experiments between LOREX and FRAM I.

(C) FRAM I

- Location: 500 km north of Nord on the northern flanks of the Mid-Ocean Ridge at approximately 020°W 85° 30'N.
- Time Frame: The proposed drift would occur in March/April 1979 as a complementary effort to the Canadian Lomonosov experiment.

- International Coordinators:

Dr. Yngve Kristoffersen Norsk Polar Institutt,
Oslo, Norway

Dr. Jorgen Taagholt Technical University
Lyngby, Denmark

020°W 85° 30'N

- Approach: Establish a 12 man ice camp at approximately

- Scientific Objectives:

<u>Disciplines</u>	<u>Project</u>
Marine Geophysics	Establish array of continuously recording sonobuoys for monitoring of micro-earthquake activity and permanent layout for seismic refraction experiments. Continuous gravity and seismic reflection.
Glaciology	Monitor ice drift and convergence, surface and seawater temperatures at 3 or 4 observation points within 100 km of the ice camp.
Marine Geology	Pre-Quaternary and Quaternary paleoclimatological studies of sediment cores. Shallow seismics. Geochemistry of the water column.
Cosmic Physics	Three component measurements of the geomagnetic field. Continuous recording of magnetic micro-pulsations. Recording of ELF/VLF emissions and infra sound.
Air Pollution	Observations of aerosol concentration on the ice island and during support flights.
Biology	Studies of nutrients and plankton in the marine habitat. Quantitative and qualitative studies of fish, birds and mammals in areas of open water. Population studies, particularly polar bears.
Physical Oceanography	Temperature/salinity structure of upper 750 m. Current observations in upper 200 m scattering layer definition.

(D) EAST GREENLAND DRIFT

- Location: Seaward of Nord, Greenland at approximately 79°N. 8°W. and 79°N. 2°30'W. See Figure 10.

- Time Frame: 1-15 April 1979

- Investigators:

Dr. Knut Aagaard, University of Washington, Seattle,
Washington
Dr. Tore Vigne, Norsk Polarinstitutt, Oslo, Norway

• Approach: It is planned to install two current meter arrays beneath the ice in the axis of the East Greenland Current. Approximately one week of operation will be required on the pack ice. Three environmental data buoys will be installed for the Norwegian Polar Institute. It is planned to use Nord as a logistic base.

• Scientific Objectives: The East Greenland Current represents the major outflow of water and ice from the Arctic Ocean. On the average, over 7 million metric tons per second exit with this current and the latent heat exchange with the Arctic Ocean. The current exercises substantial control over acoustic, ice and near-surface conditions in large parts of the seas through which it flows, and its influence extends more than 4000 kilometers from its origin northeast of Greenland. The immediate objectives is to obtain several long-term Eulerian time series of currents in the northern part of the East Greenland Current, so as to define the low-frequency motions and shears in particular. At the same time, moorings funded by NSF will be in place farther east, across the West Spitsbergen Current, so that the low-frequency behavior of these two important streams can be compared.

(E) ARCTIC ACOUSTICS

• Location: 200 to 500 km off Nord seaward of the continental shelf

• Time Frame: MARCH 1979

• Investigators:

Mr. Beaumont M. Buck, President, Polar Research Laboratory

• Approach: Establish two or three man ice camps within 20 km of each other

• Scientific Objectives: Measure ambient noise levels in the Arctic. Determine acoustic propagation by detonation of various charges away from the camp and using explosive charges of opportunity from LOREX and FRAM I.

(F) COASTAL DYNAMICS

• Location: For two weeks in April a field program will be conducted out of Ny-Alesund, Svalbard. In July - August field camps will be established on Prins Karls Forland and Kvadehuken, Svalbard.

• Time Frame: April and July - August 1978

• Investigators:

Rouge, Louisiana Dr. William Wiseman - Louisiana State University, Baton

Dr. Tore Gjelsvik - Norsk Polarinstittut, Oslo, Norway

• Approach: The fjords of Svalbard provide excellent laboratories for studies of Arctic coastal dynamics. With cooperation and participation by Norwegian scientists a field effort is now underway in Svalbard. Support is obtained locally in Svalbard.

• Scientific Objectives: During this study two main problems will be addressed. These are (1) characterization of the progressive variations of fjord shorelines from the open ocean to the head of a fjord, as a function of the variability of the process environment, and, (2) characterization of the dynamic processes responsible for the distribution and transport of suspended sediment within a fjord.

**ENVIRONMENTAL RESEARCH
SUPPORTING ARCTIC NAVAL OPERATIONS
FIG. IN \$000**

MAJOR THRUSTS	FY 77	FY 78	% OF TOTAL THRUST - FY 78	FY 79	TREND
Arctic Environment	799	956	24%	1630	↗
Remote Sensing	70	400	10%	623	↗
Crustal Geophysics	42	100	2%	510	↗
Acoustics	318	550	13%	1110	↗
Environmental Prediction	246	340	8%	740	↗
Research Support	1800	1800	43%	**	
Logistics, Tech. Trans., etc.				555	↗
TOTAL	\$3255	\$4146	100%	*\$5168	↗

**Congressional Submission*

***Logistic Costs Integrated Into Major Thrust Budgets*

Figure 1

CONTRACT RESEARCH PROGRAM

Universities	20
Navy Laboratories	3
Other Navy	1
Non-Navy	2
Private Industry	2
Non-Profit	2
	<hr/>
	30

Figure 2

INTERFACE WITHIN ONR

	Codes									
Effect of Environment	486	485	484	483	482	481	480	479	478	477
Climatology/Meteorology	✓*									
Physical Oceanography		✓								
Geologic Processes		✓*								
Ice Physical Properties					✓*					
Crustal Geophysics/Geodesy			✓*							
Acoustics	✓		✓							
Remote Sensing		✓		✓						
Environmental Models					✓	✓				

* JOINT FUNDING

Figure 3

INTERFACE WITH NAVY LABORATORIES

NSWC: Coordinated investigation of effect of Arctic environment on mines

NUSC: Project Tristen Development of Arctic underwater communications

NOSC: Basic research and logistic support for SUBICEX

CEL: Physical properties of Arctic ocean sediments

NORDA: Aeromagnetics and remote sensing of sea ice

NRL: Crustal geology / geophysics, acoustic scattering, SAR digital processing

Figure 4

ACTIVE INTERFACE WITH NAVY

Ice distribution modeling

FLT NUMWEACEN
FLT WEAFAC, Suitland
NORDA, Naval Post-
graduate School
NEPRF

Arctic Aerosol
Arctic Aeromagnetics
World Relief Chart

Figure 5

ACTIVE INTERFACE WITH DoD

DMA
DMA
USAF
USA
Arctic bathymetry
World Relief Chart
Arctic Aerosol
Remote Sensing /Ice Dynamics

INTERAGENCY EFFORTS

Define Arctic engineering technologic deficiencies	ERDA NOAA NSF	NOAA NSF IARCC	Dept. of State DOT, NASA
Ice distribution modeling			
Arctic research			
Arctic planning			
Coastal dynamics in Svalbard			
Remote Sensing			

Figure 6

INTERNATIONAL COOPERATIVE EFFORTS

Arctic Acoustic Reverberation (CANBARX)	Bedford Institute, Canada
Arctic Aerosols	Research Institutes of Northern Nations
Coastal Dynamics	Norsk Polarinstitutt
Marginal Ice Zone	Scott Polar Research Inst. Danish Meteorologic Inst.
FRAM 1	Research Institutes Canada, Norway, Denmark
Svalbard Open Water	Geophysical Institute University of Bergen, Norway
Remote Sensing	Defense, Canada

Figure 7

6.1 BASIC RESEARCH
RDT&E PLANNING CATEGORIES

SCIENTIFIC CATEGORIES	STRATEGIC DETERRENCE	SEA CONTROL	PROJECTION OF POWER ASHORE	MISSION SUPPORT	PERSONNEL/MEDICAL	
					8	9
I. EFFECTS OF ARCTIC ENVIRONMENT						
A. CLIMATOLOGY/METEOROLOGY	I				S	S
B. PHYSICAL OCEANOGRAPHY	I	S			S	S
C. MARINE BIOLOGY	I				I	S
D. GEOLOGY	S	S			S	S
E. ICE	S	S			I	S
III. REMOTE SENSING					S	I
III.I. CRUSTAL GEOPHYSICS/ GEODESY	S	S			S	S
III.IV. ACCUSTICS	S				S	S
III.V. ENVIRONMENTAL MODELS	S				S	S
VI. MATERIALS					S	

I = IMPLIED REQUIREMENT

S = STATED REQUIREMENT

Figure 8

TECHNOLOGY TRANSFER

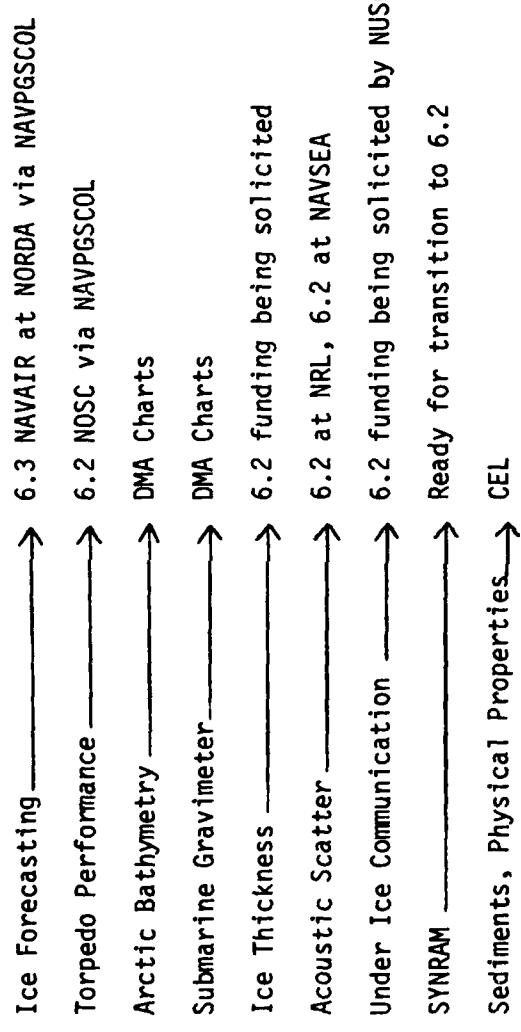
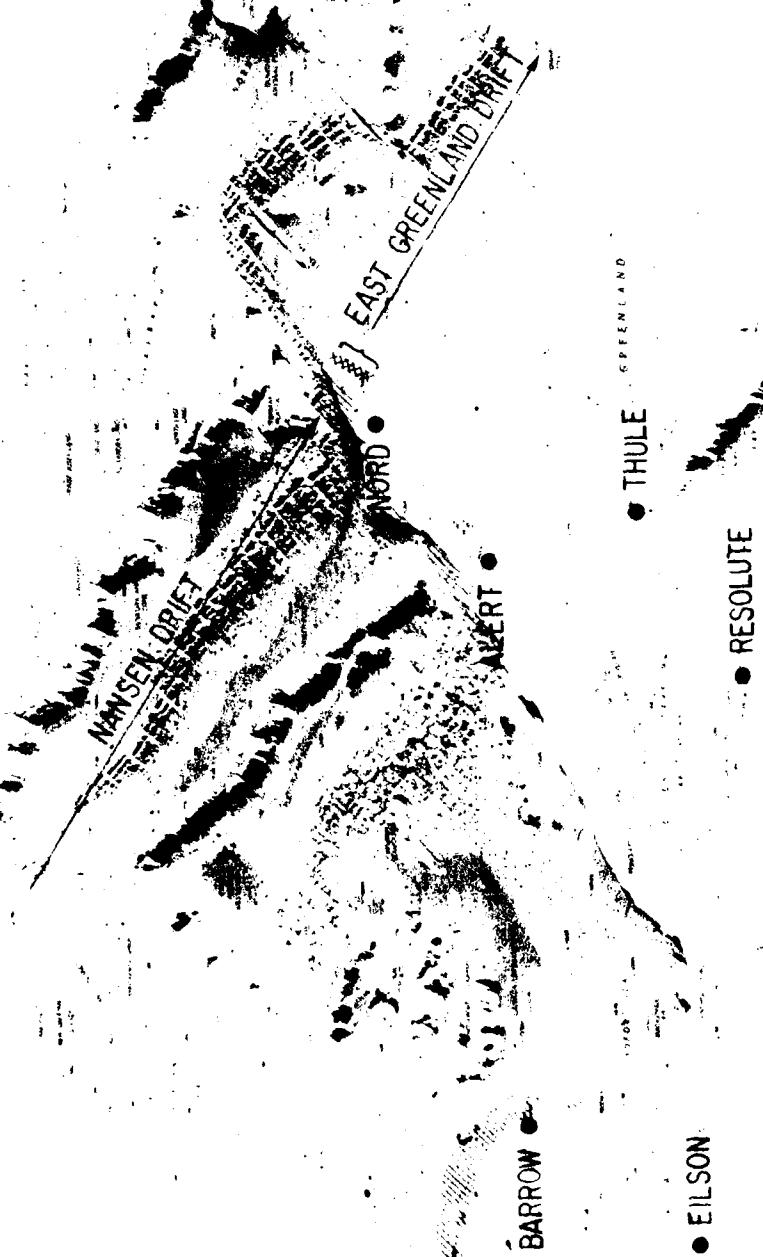


Figure 9

ARCTIC OCEAN FLOOR



GEOGRAPHY PROGRAMS

J.S. BAILEY, 696-4025

ONR CODE 462

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GEOGRAPHY PROGRAMS

Figure 1 states the purpose and major objectives of the program.

Our approach to coastal research is fundamentally distinctive,

1) we are world-wide while others are dedicated to domestic studies,
2) our concern is being able to make a prediction of short term
changes in coastal conditions, and 3) it is our policy to emphasize
research in many kinds of coastal environments and we put a premium on
understanding individual physical processes such as wave dynamics,
current dynamics, sediment transport, etc. within the context of the
environment as a whole. Without this approach, one can - and does -
wind up with 19 different equations for the longshore transport of
sand with no guidelines to relate the equations to the particular
environments for which they were calculated. Figure 2 shows the sub-
programs and funding dedicated to achieving the major objectives or
thrusts of the program; they will be discussed individually.

RELATION TO NAVY NEEDS:

Geography Programs provides an effective coordination center for
coastal environmental studies within the Navy and Marine Corps, DoD,
other government agencies, nonmilitary organizations, societies, edu-
cational institutions, and individuals. The program is also deeply
involved with coordinating and cooperating in research efforts of a
similar nature being conducted on foreign shores. Figure 3, for example,
shows the extent of our foreign involvements over the past five years

and what we anticipate for the near future. Our anticipated research project in Egypt is now a reality; five of the Louisiana State University (LSU) research team are leaving for the area the 14th of this month. The Navy needs and has in Geography Programs a single activity having almost complete cognizance of the research area.

RELATION TO ONR:

Our program blends within the ONR structure by relating research to Naval-Marine Corps needs in the coastal environment and by conducting research of a fundamental nature; research looking into the why and how of dynamic coastal processes. We attempt to determine the feasibility of furthering various concepts and applications of instrumentation and techniques to a unique and hostile operational environment. These determinations are requisite to achieving a capability for predicting changes in conditions in this environment.

You will see shortly, how we are constrained in our studies by the time and space scales of motion of the shallow water processes as well as by Naval-Marine Corps requirements.

WHAT HAPPENS TO OUR RESEARCH ITEMS:

Figure 4 serves to show the flow of our research to the user community and their end products.

COASTAL DYNAMICS

The objective of coastal geography programs is to achieve a basic physical understanding of coastal shallow water environmental parameters and their combined processes. It is through this knowledge that we are developing a capability for predicting changes in these dynamic processes that directly affect coastal land forms and military operations in coastal waters.

WHAT FACTORS GOVERN OUR RESEARCH:

The following figures 5,6,7, depict hydrodynamic and atmospheric motions according to the characteristic time and length scales of motion.

You will see that in our research program the emphasis is on those motions that fall somewhere in the middle of the range.

In general, our interest is in those motions that can have significant effects on the nearshore and inner shelf regions over the time scale of a military operation -- say several hours to several days.

In the case of waves, (Figure 5), we have greatest interest in surface waves -- including breakers, storm waves, and swell. Tides and storm surges are the focus of modeling efforts designed to provide adequate input data to our coastal process models.

The main emphasis on currents (Figure 6) is on wave driven currents (important in the nearshore zone) and larger scale currents that are important a bit farther offshore. Again, tidal currents are treated as an input factor.

Finally, in Figure 7, we see the atmospheric motions that are of most importance in coastal research tend to fall in the middle range -- sea breeze systems, fronts, hurricanes, and high- and low-pressure systems. The larger scale motions such as monsoon regimes and climate are important in understanding the spatial variability of coastal environments, and we consider these motions in devising classification schemes for coastal types.

The previous three slides delineated the scope of our program in the context of coastal processes of various time or length scales. For management purposes, however, we find it more effective to group our projects in a somewhat different scheme; namely, nearshore dynamics, shelf processes, and coastal class studies.

NEARSHORE DYNAMICS:

The nearshore dynamics effort (Figure 8) provides typical examples of the type of coordination we try to foster in order to create a research program as opposed to a group of isolated contracts. Drs. Thornton and Inman will be working together for the second successive year in their summer field work. This year, they will be joined by Dr. Dalrymple of Delaware (the co-principal investigator) who is spending a sabbatical at Scripps., besides performing his own part of the field research. Dr. Dalrymple will be trying to incorporate the research results into the nearshore computer model being developed by himself and Dr. Wang. Figure 9 serves only to show you how all of the individual coastal dynamic and shelf process studies will ultimately fit together and be

integrated into Wang's and Dalrymple's nearshore model. The dynamics and shelf process studies are directed toward formulating this model's components.

SHELF PROCESSES:

Figure 10 depicts our shelf processes research where we have two new efforts. Dr. Southard at MIT is performing a combined laboratory and field effort in an examination of the large sand waves that are present in many types of coastal environments. At the Waterways Experiment Station at Vicksburg, we are partially supporting a promising new approach to the problem of storm surge prediction in coastal areas. In some respects, this research parallels that of Dr. Kuo of Columbia, who is using a quite different approach in solving a similar problem. Each approach has distinct advantages and disadvantages, and we are looking closely at both to see which will ultimately be of the greatest benefit from the Navy standpoint. Here again, there is close coordination between complimentary efforts.

COASTAL CLASS STUDIES:

Three efforts winding down in Coastal Class Studies, shown in Figure 11, the work in Surinam, Nicaragua, and the Persian Gulf has been highly successful, and we expect to see certain aspects of this research pursued in future projects.

The new effort this year in coastal class studies is that of LSU's Nile Delta work. Here we are conducting cooperative research in a hyper saline, arid environment where the dynamics of wave, current, and sediment

interactions are unknown or at best very poorly known. These studies provide information on how to determine which model to use where and when.

I should like now to briefly discuss a topic of our research that you may not be aware of.

Coastal meteorology is an integral part of the total-systems approach to understanding coastal environments. This is an area that we have not gone into in great detail in recent reviews, and I would like to bring you up-to-date on some recent advances. The work which I will describe has been performed by the staff of the Coastal Studies Institute of Louisiana State University, particularly by Dr. S. A. Hsu. One of the most important parameters in modeling coastal processes is the wind stress at the sea surface. A knowledge of wind stress permits calculations of wave growth, wind-driven currents, and local heat budgets. Wind stress is dependent on either the shear velocity or the surface drag coefficient, and in the past, there have been as many estimates of drag coefficients as there have been investigators. Dr. Hsu, however, has derived a general expression for the calculation of wind stress that is easy to use and is highly accurate. This expression $\frac{2\pi Z}{(H/C^2)} = U_*^2 \exp(\kappa U_2/U_*)$ relates the shear velocity (U_*) to the wind measured at some height Z , usually ten meters. Unlike the normal logarithmic profile normally used (top equation), this expression takes into account the variability of the wavy sea surface; H is the local wave height and C the phase velocity of the dominant component. Hsu has taken this equation and produced a nomograph (Figure 12) for the rapid calculation of stress. This new technique is becoming widely accepted in the air-sea

interaction community, and it represents a major advance. Measurements of the wind at several levels also gives a picture of the air flow regime at the coastal boundary of land and sea. Experiments performed in many types of coastal regions have shown clearly how the wind profile changes substantially when going from smooth tidal flats to rough dune topography. These results have been successfully applied to the prediction of beach sand transport by wind. In addition, these experiments have been of direct benefit to LSU's studies of marine aerosols in the coastal zone. Field experiments in Texas and the Caribbean have enabled Hsu and his coworkers to develop a picture of the aerosol dispersion process in terms of aerosols that are trapped within the coastal boundary layer. These experiments have led to the development of a preliminary model of aerosol concentration that is very promising. (Figure 13) This is the output of the model, which shows aerosol concentration as a function of height z . The coefficient of z and the exponential factor of z are derivable from known meteorological and oceanographic parameters. The additive term is a source term which at the present is derived from curve fitting. In time, we expect that it, too, can be independently derived. The fit, as you see, is quite good.

One thing that has become clear is that the concentration of aerosols becomes much higher in coastal areas during the night, and the reason for that is the behavior of the coastal inversion cycle. During the night, cooling induces a coastal inversion and a lowering of the atmospheric boundary layer. Under such conditions, aerosol concentrations can reach several times the daylight values.

Dr. Hsu's studies of coastal atmospheric boundary layer processes also have a direct bearing on the remote sensing of coastal physical parameters. The structure of the atmosphere, the changes induced by frontal passages, and the specification of parameters such as precipitable water are all applied to such problems as satellite sensing of sea surface temperature, such as the work being done by Dr. Huh at LSU. Here (Figure 14) we see the absorption of IR energy by free water in the atmosphere, i.e. a polar U.S. marine air mass -- with sufficient moisture to obliterate the signal from the Gulf Stream in this area. The polar air mass north of Lake Okeechobee, Florida had a relative humidity of 30% while the marine air mass to the south yielded a reading of 60%. A visual band photograph of this same scene would have shown a clear, cloud-free region.

COASTAL REMOTE SENSING

Our remote sensing program primarily has concentrated on determining the feasibility of using various sensors to measure specific coastal parameters. We must know the capabilities and limitations placed upon these instruments by the rapidly changing coastal/ocean and atmospheric environments. Figure 15 shows the funding level for this subprogram.

The proliferation of remote sensing demands that we be alert to the field as a whole and specifically, the research and applications aspects. Our job here then is to learn how we can apply remote sensing technology to help meet Naval/Marine Corps needs -- at least in so far as it relates to our coastal dynamics studies.

We are now at the stage in this program where we have begun the transitioning from surface and aircraft remote sensing to satellite applications. We are in close coordination with Code 480 and others and are presently assisting in the development of a capability at SCRIPPS to acquire, reduce, and use, in real time satellite data for use in research in our respective areas.

In keeping with what has been said previously, these projects serve to point out the very basic nature of this research program. For example, Dr. Leonard has developed the use of Raman spectroscopy for sensing atmospheric parameters. He is now engaged in determining the feasibility of obtaining Raman spectra from coastal waters to obtain temperature and salinity measurements in real time as a function of depth.

A pulsed laser transmitter operating in the visible portion of the spectrum near 5000 Å is used to illuminate ocean subsurface waters. The Raman backscattered light is detected and analyzed in real time to obtain temperature/salinity as a function of depth.

In brief the Raman phenomena can be described as spectrometer observed backscattered light from the illuminating source where the monochromatic wave length of the transmitted light is shifted (in the case of H_2O - towards the red about 800 Å, and broadened.)

A spectrometer scanning the shifted and broadened Raman water spectrum observes and records a composite spectra from the polymer ($\lambda 2$) and monomers ($\lambda 1$) as shown in Figure 16. The ratio of the polymer to monomer spectra is temperature dependent. Analysis of the sum (Composite spectra) to a precision of 1% yields a temperature measurement

of 1°C accuracy. Coupled with the gating capability of the lidar system, temperature as a function of depth is obtained. The use of dual polarization techniques is expected to make possible measurements to several attenuation lengths in depth.

Remote Sensing over some quite important coastal ocean areas is often difficult to impossible as a result of cloud cover or other atmospheric attenuation factors. Radar is a means of overcoming these problems and has become a very important sensing tool. The problem with most conventional active and passive radar systems is that they have gross resolution cells resulting from the need for prohibitively large antennas. To overcome this, the Synthetic Aperture Radar (SAR) has been designed which is cloud-penetrating and capable of giving images with good resolution. The SAR should almost by definition not work when the target, such as waves, is moving. Surprisingly, however, it does work, but it is difficult to interpret the results.

Many scientists are looking forward with great enthusiasm to the prospect of using the space derived high resolution (SAR) wave data for research purposes and for driving various predictive models. Several problems are evident with the SAR, however, and Dr. Shuchman of ERIM is now making inroads on the solutions to these problems.

For example, the SAR is designed to image a stationary target at large incident angles. SEASAT, however, images a moving target at small incident angles. The result is a defocusing and displacement effect. Figure 17 demonstrates the phenomena quite well. Realize then what must occur when a wave approaching the coast changes direction, shape, and speed.

Also, one must realize that unlike other radar data the SAR raw data must be reduced to produce an image. Dr. Shuchman has already solved some of these problems and has, by his investigations, become the outstanding expert on SAR technology. We are confident that we shall obtain measurements of wave lengths, wave directions, and probably wave heights by SAR sensing, and we will learn of the capabilities on limitations of the SAR, i.e. at what point the reliability, and accuracy or resolution begin to deteriorate and to what degree the information can still be used.

SYSTEMATIC GEOGRAPHY

We recognize in this program the need for quickly and accurately entering significant, nonredundant data into a coastal data base or, as required, into an appropriate computer complex to drive predictive models for specific coastal operations.

Figure 18 indicates the budget and research categories that the projects address.

In past sessions such as this I have talked about the research of Drs. Peucker, Gerhardt, Dolan/Hayden, but in view of recent DOD interest in one of our projects I would like once again to mention the work of Dolan/Hayden et.al. at the University of Virginia. I am referring to their sequence of research projects beginning with a coastal classification scheme progressing with a wave climate calendar and now broadening into a coastal information referral system. An article by Dolan, et.al. in

our recent issue of Research Reviews gives a detailed account of this referral system and I urge you to read this.

I have been asked to respond to the questions: 1) Where do we stand in our program?, and 2) What research opportunities do we expect?

The first question of where we stand is difficult to answer since there is nothing with which to compare our program. I shall, therefore, attempt to answer in this way. We have developed many isolated predictive process models that respond to simple coastal conditions. We can with these models predict changes in coastal conditions with varying degrees of success. Several of the models, such as the inshore current prediction model are being expanded to include complex coastal areas.

Many of the process models are now being incorporated into the "Masters" model of Wang and Dalrymple mentioned previously.

A single model to predict the changes in wave characteristics as they proceed from deep to shallow water to breaking on the beach is now being finalized for turnover to the Marine Corps, SURFLANT, and NSRDC. We have made great progress in the past 5 years.

What research opportunities do we expect? Without hesitation the virtual proliferation of satellite systems this year will really make a staggering impact on our research and Naval operations. As I mentioned, we have already begun our satellite related research. Also, we have initiated action with NATO and other European nations on coastal data exchange agreements and possible cooperative and mutually beneficial research projects. This will open up many research opportunities at a variety of coasts.

Mr. Dolezalek will discuss the status of these initiatives.

TRANSITIONING OF RESEARCH PROJECTS

Our products are not hardware, they are mainly software packages which means we are looking for input to minicomputers for specific actions. Our product is then generally not one for Navy-wide use.

None-the-less instances have and will continue to occur in that we do have a good product to move forward for fleet use. Examples are the data referral system now being readied for transfer to FNWC, our environmental data buoy which will be used in the coming amphibious operation "SOLID SHIELD," and the laser bathymetry system that was picked up and built and is now being test flown by NASA. Additionally, our wave characteristics model is being readied for transfer to SURFLANT and NSRDC.

GEOGRAPHY PROGRAMS
CODE 462

PURPOSE

To provide the Navy and Marine Corps with the knowledge and techniques for making accurate and real time observations, assessments, and predictions of environmental conditions and changes that may be encountered along coastal areas of the world at any time.

OBJECTIVES

To provide the capability to accurately model and predict coastal dynamic processes

To provide the tactical capability to remotely sense coastal environmental parameters

To provide the real time capability to process, analyze, and display coastal environmental information

GEOGRAPHY PROGRAMS

<u>SUB-PROGRAM</u>	<u>PROGRAM OFFICERS</u>		
Coastal Remote Sensing	Dr. J. S. Bailey, Director		
Coastal Geography	Mr. D. Conlon		
Systematic Geography	Mr. H. Dolezalek		
Funding (\$K)	<u>FY 77</u>	<u>FY 78</u>	<u>FY 79</u>
	1625	1925	2382*

*Congressional Submission

Figure 2

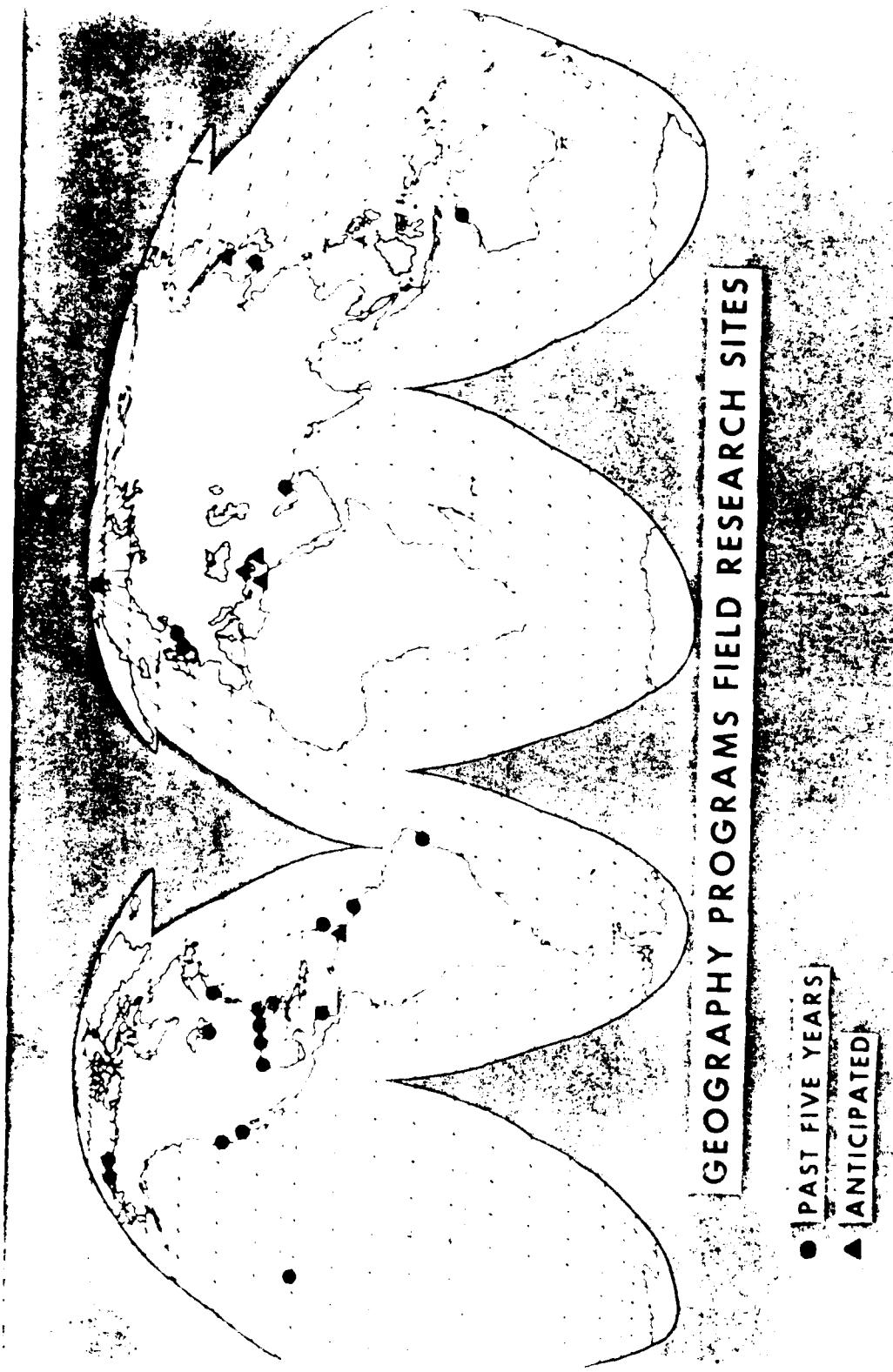
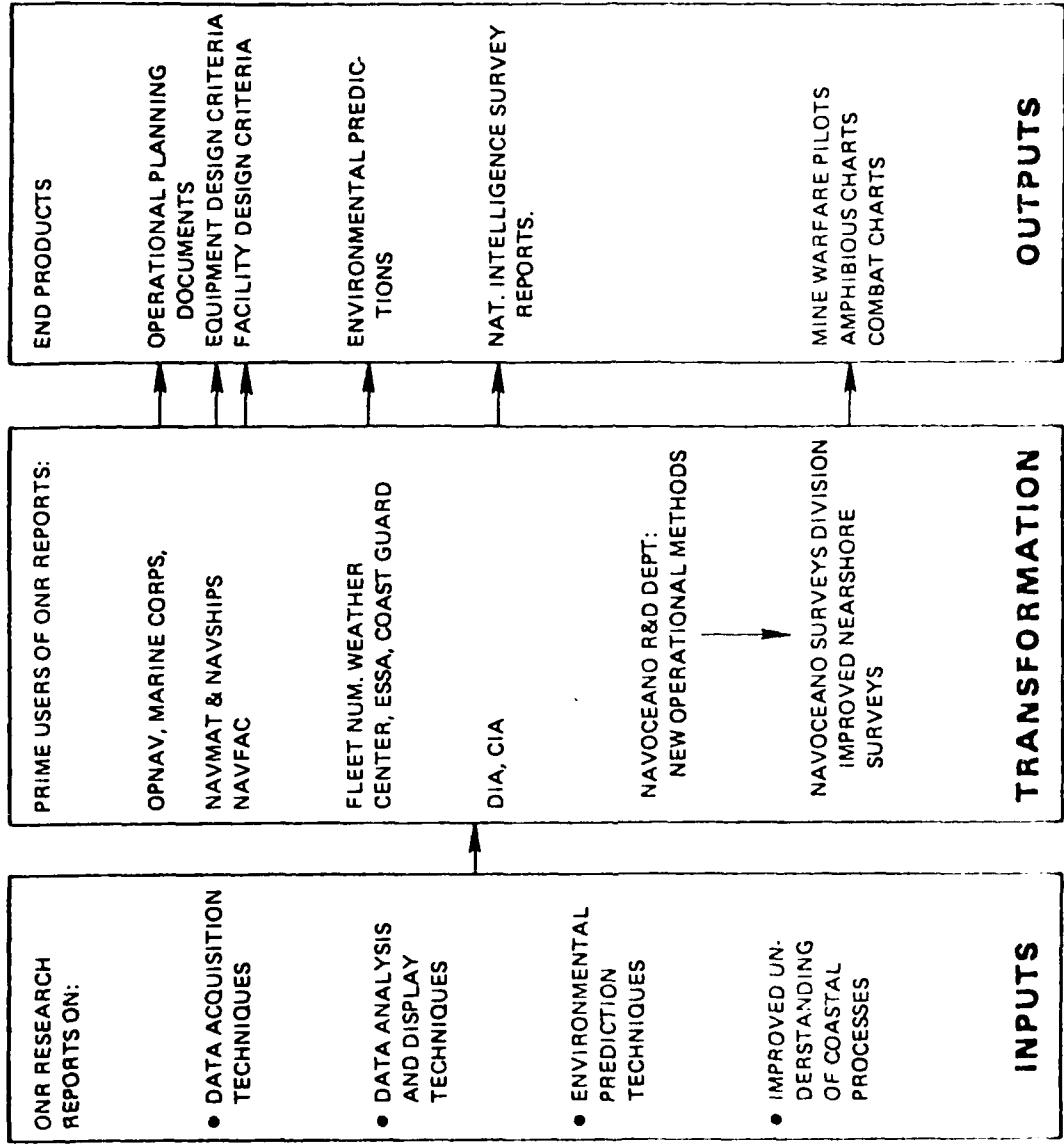


Figure 3

USE OF ONR COASTAL RESEARCH INPUTS



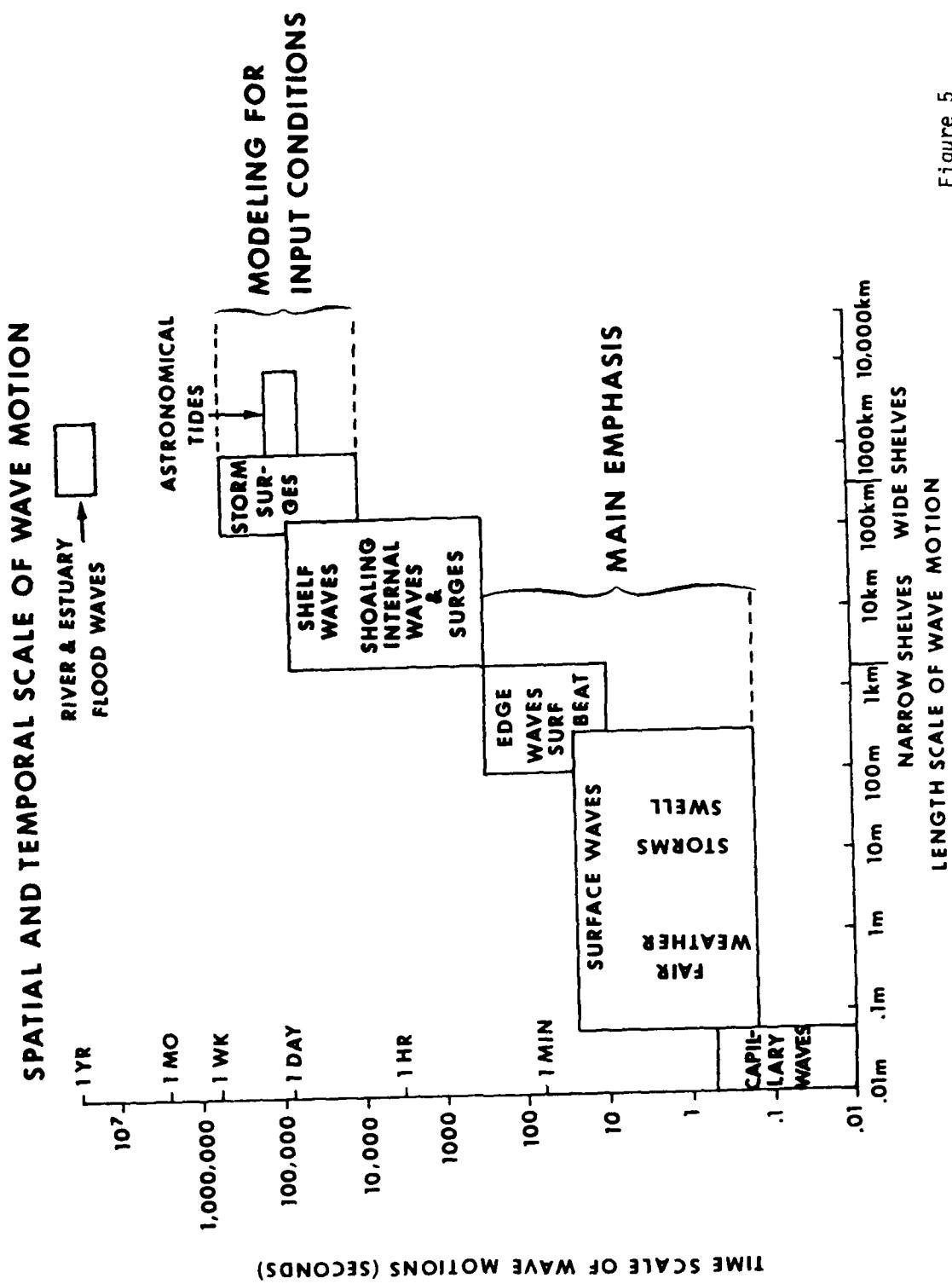
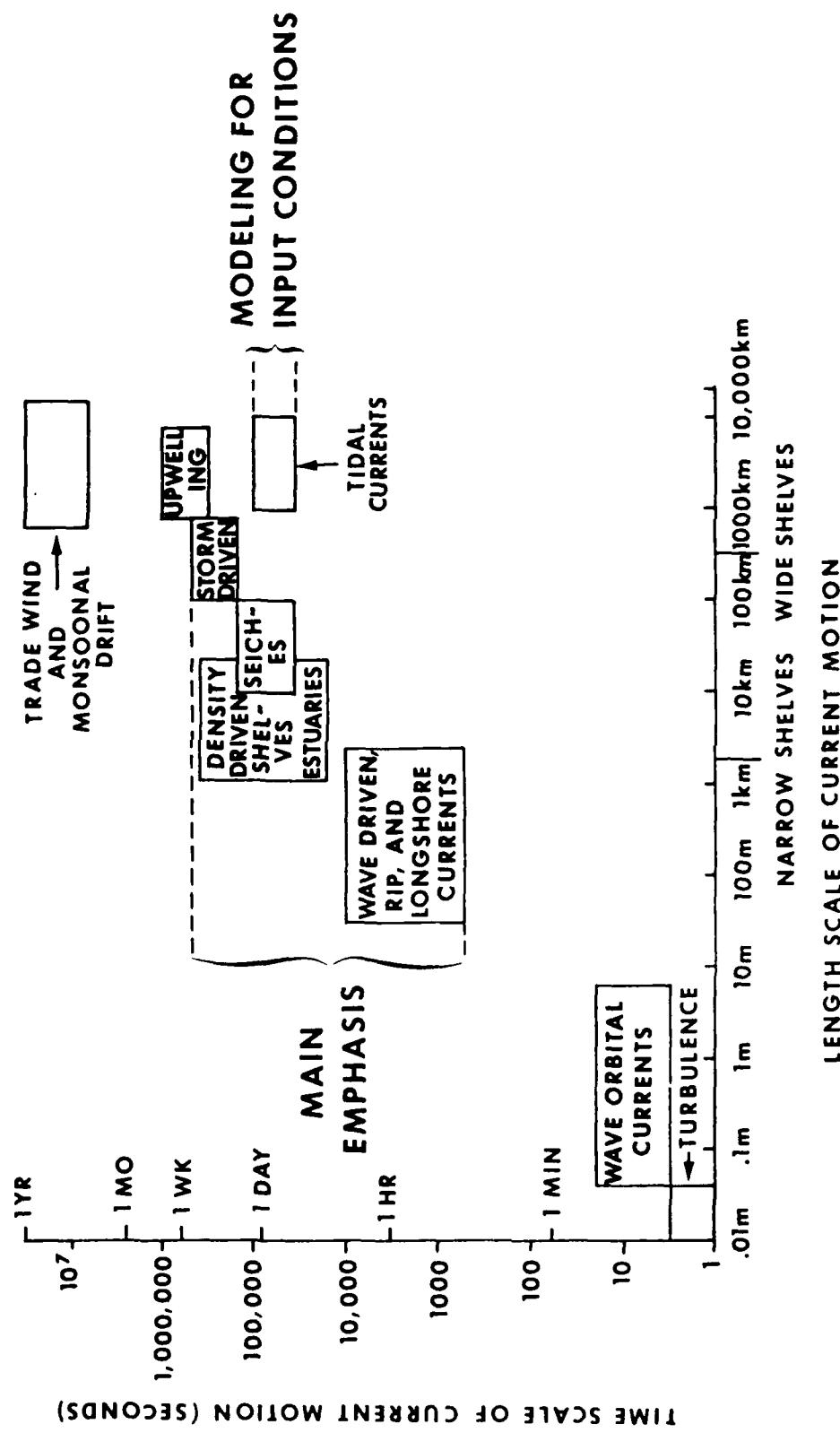


Figure 5

SPATIAL AND TEMPORAL SCALES OF CURRENT MOTION



SPATIAL AND TEMPORAL SCALES OF ATMOSPHERIC MOTION

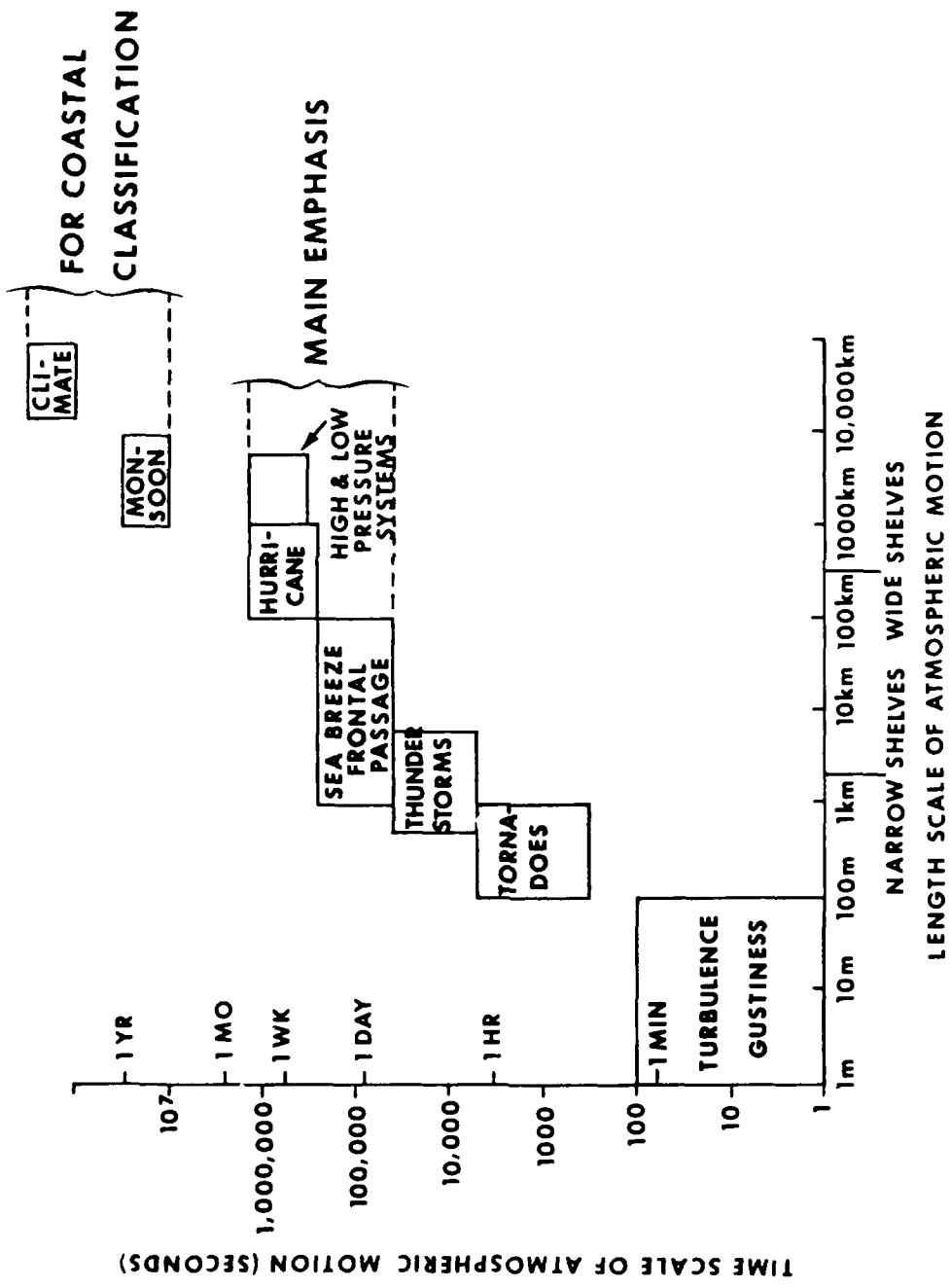


Figure 7

GEOGRAPHY PROGRAMS

NEARSHORE DYNAMICS

CONTRACTOR	AREA OF INVESTIGATION	FUNDING LEVEL (FY78)
SCRIPPS I. O. (Inman)	SHORE DYNAMICS	157K
NPGS (Thornton)	BREAKING WAVES	33K
PURDUE U. (Wood)	LONGSHORE CURRENTS	10K
BOSTON C. (Brenninkmeyer)	ONSHORE TRANSPORT	35K
U. DELAWARE (Wang)	NEARSHORE MODEL	65K
VIMS (Goldsmith)	BAR FORMATION	40K

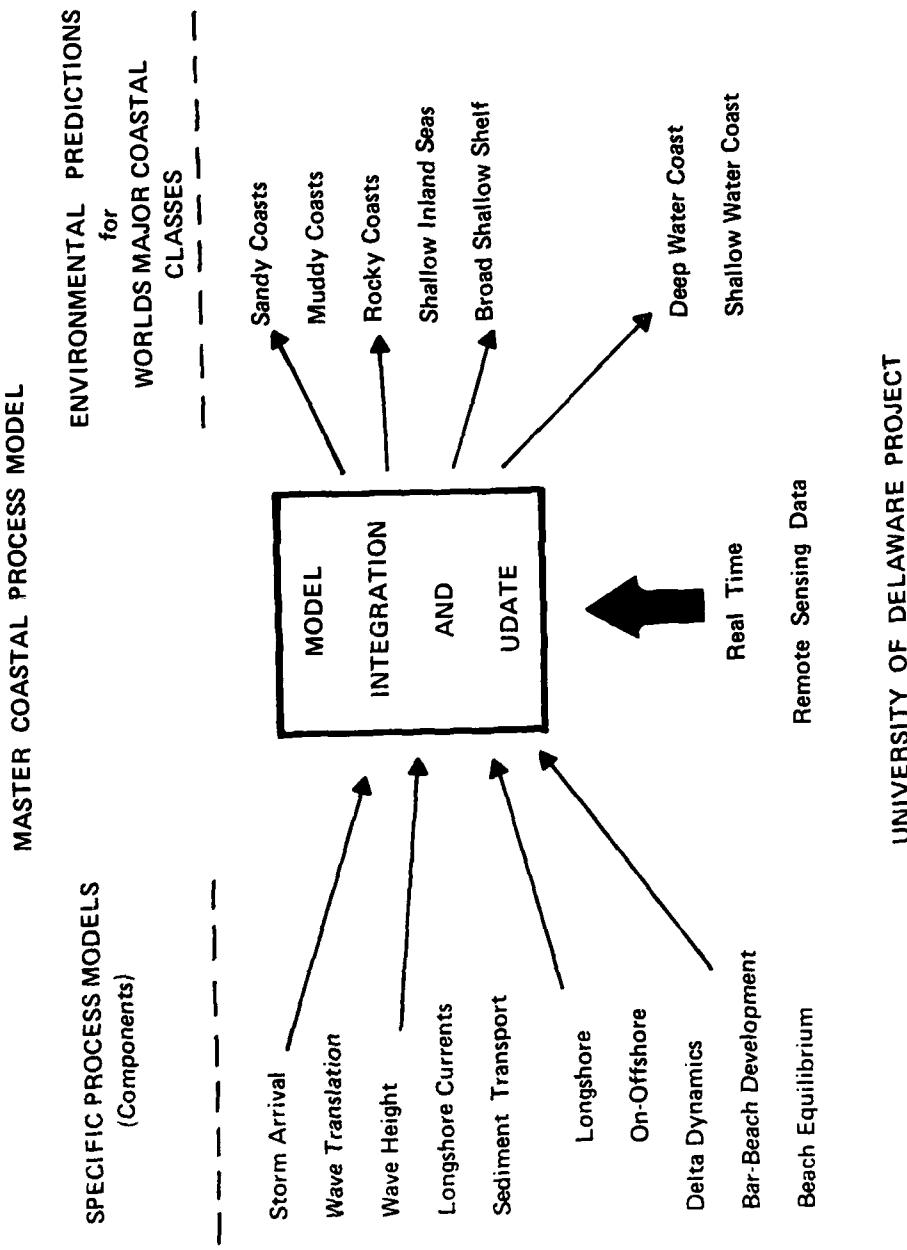


Figure 9

CONTRACTOR	AREA OF INVESTIGATION	FUNDING LEVEL (FY78)
COLUMBIA U. (Kuo)	OPEN COAST TIDE MODEL	64K
MIT (Southard)	TIDAL SAND WAVES	59K
WES (Whalin)	STORM SURGE MODEL	15K
LA. STATE U. (Suhayda)	COASTAL SEA STATE	60K
FLA. STATE U. (Breeding)	WAVE PREDICTION MODEL	60K
U. SO. FLORIDA (Davis)	BEACH-INLET TRANSITION	31K

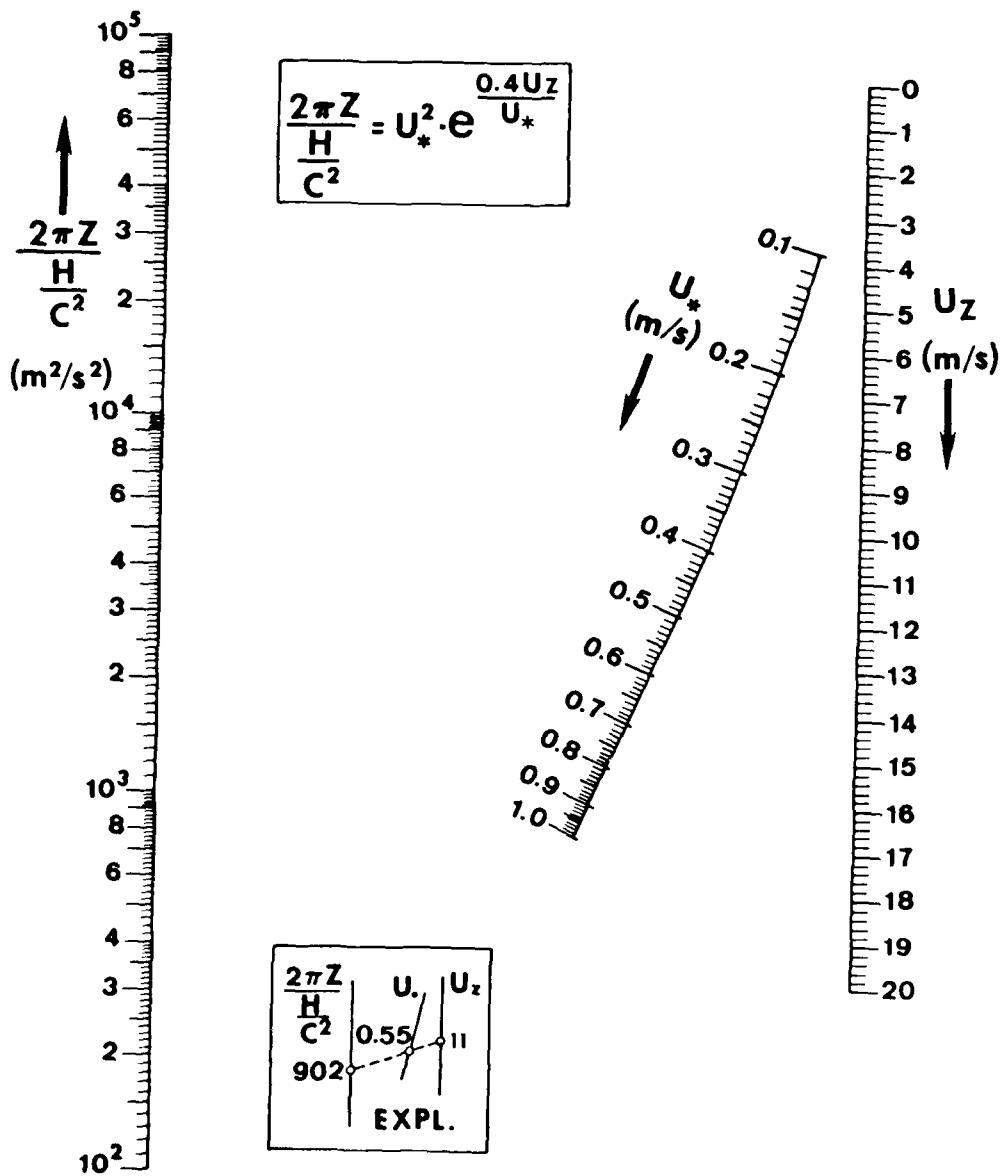
GEOGRAPHY PROGRAMS

COASTAL CLASS STUDIES

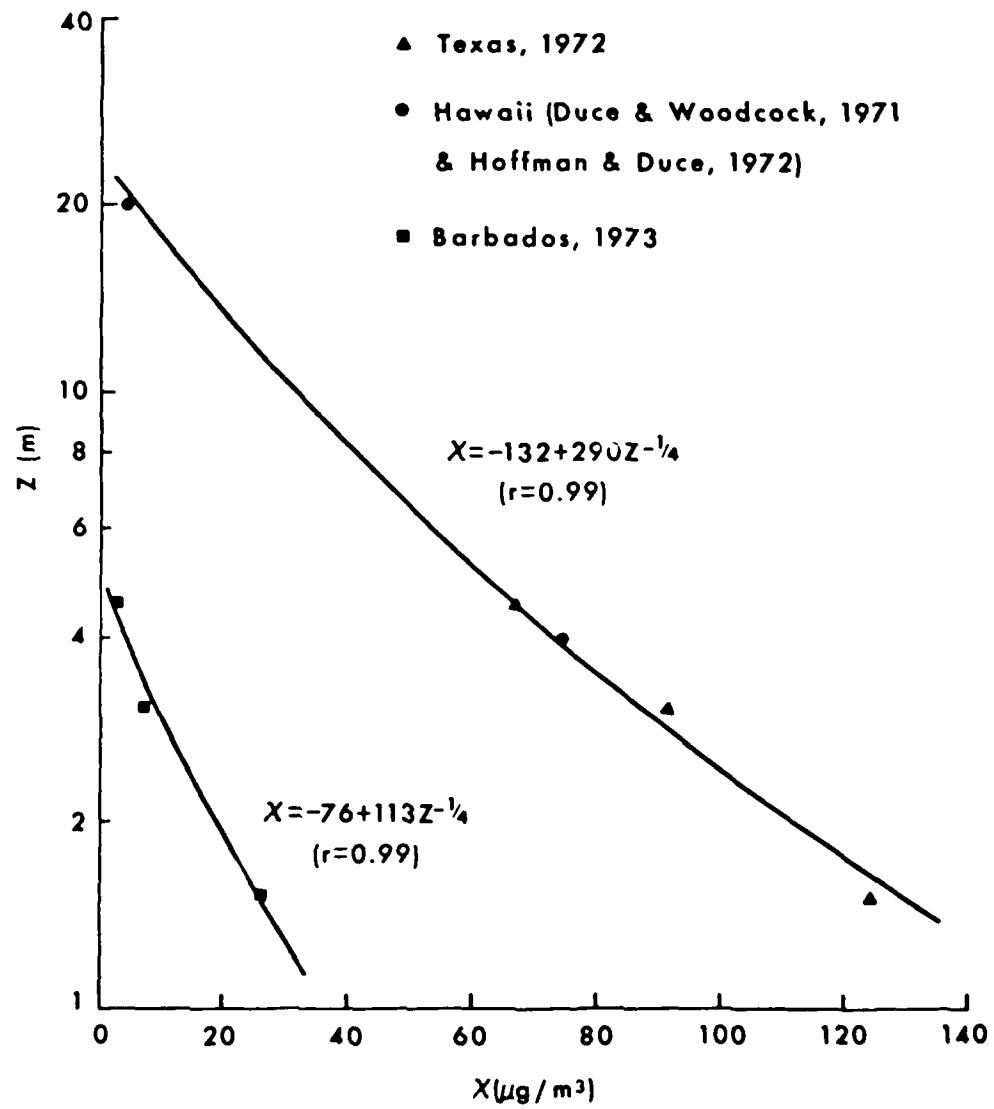
CONTRACTOR	AREA OF INVESTIGATION	FUNDING LEVEL (FY78)
L.A. STATE U. (Coleman)	Arid Delta Coast (Egypt)	150K
U. NOTTINGHAM (King)	Tide-Dominated Coast (England)	20K
U. DELAWARE (Kraft)	Reconnaissance of Turkey	20K
		40K
L.A. STATE U. (Coleman)	Muddy Coast (Surinam)	40K
L.A. STATE U. (Murray)	Shallow Bank Shelf (Nicaragua)	55K
TETRA TECH INC. (Sonu)	Shallow Inland Sea (Persian Gulf)	10K

Figure 11

NOMOGRAPH FOR CALCULATION OF WIND STRESS



AEROSOL CONCENTRATION MODEL OUTPUT SHOWING
CONCENTRATION AS A FUNCTION OF HEIGHT Z



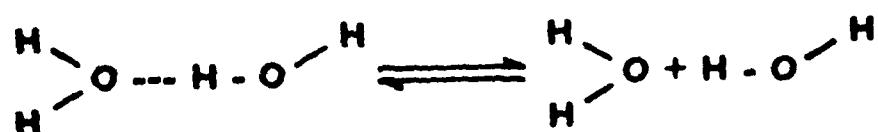
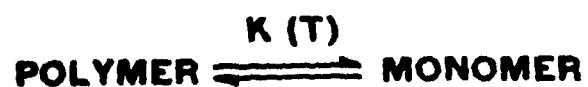
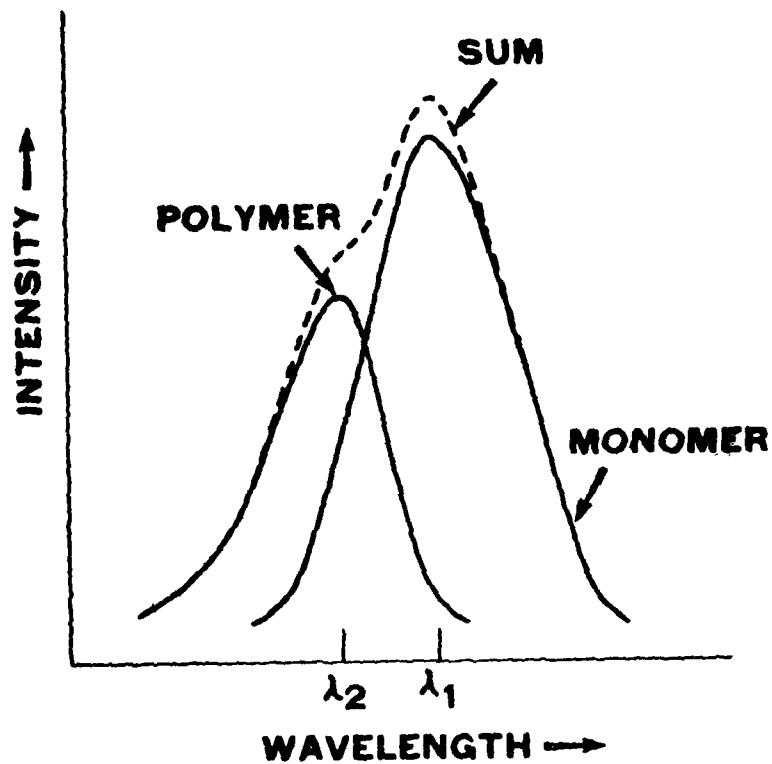


COASTAL REMOTE SENSING

FUNDING (\$K)	FY 77	FY 78	FY 79*
	264	430	633

*Congressional Submission

A COMPOSITE SPECTRA AS DERIVED FROM
THE MONOMER AND POLYMER SPECTRA



$$I(\lambda_1)/I(\lambda_2) \approx (\text{MONOMER})/(\text{POLYMER}) = K(T)$$



FIGURE 2

1970

1971

1972

1973

1974

SYSTEMATIC GEOGRAPHY

FUNDING (\$K)	FY 77	FY 78	FY 79*
Information Referral System	342	445	584
Data Structures			Dolan
Data Display			Sterling Ltd.
Data Enhancement			Rens. Poly. Ins. Gerhardt
			ERIM Thomson

*Congressional Submission

FIGURE 18

ENVIRONMENTAL FACTORS PROGRAM

R.G. JOINER, 696-4201

ONR CODE 465

Environmental Factors Project
(RR 03208-01)

1. The Environmental Factors Project consists of four tasks and funding as follows:

<u>Task Area</u>	<u>Funding (\$K)</u>	
	<u>FY 78</u>	<u>FY 79</u>
Environmental Effects on Strategic Communications	180	260
Tactical Communications and Surveillance Concepts	135	180
Diagnostics and Environmental Effects of Nuclear Explosions on Naval Systems	60	60
Arctic Environmental Effects on Conventional Weapons Phenomena and Sensors	80	30
	—	—
	\$455	\$530*

*Congressional Submission

2. In addition to these funds an additional \$1.14M of FY 78 were received from DNA, DCA, DARPA and AFTAC for research of mutual interest in nuclear effects, surveillance, survivability and communications. A sum of \$1.9M is expected from these sources in FY 79.
3. Each of the four tasks will be discussed in turn.

Environmental Effects on Strategic Communications

4. This is a broad area concerned primarily with the natural and man-made (nuclear) atmospheric and ionospheric environment and its effects on

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(B) Tactical Communications and Surveillance Concepts	104
(C) Diagnostics and Environmental Effects of Nuclear Explosions on Naval Systems	105
(D) Arctic Environmental Effects on Conventional Weapons Phenomena and Sensors	108

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Environmental Effects on Strategic Communications

4. This is a broad area concerned primarily with the natural and man-made (nuclear) atmospheric and ionospheric environment and its effects on

long path communications with strategic forces. Overall objectives justifying the need for research in this area are:

- Maintaining the credibility of the nuclear deterrent
- Improvement in future C³ system design
- Expansion of mission profiles through improved communications
- Avoidance of system underdesign or overdesign
- Control of system costs
- Technological spin-off to non-communication areas

5. While this task area has a number of subtasks, time will permit discussion of only two. They are the ELF Field Simulation Program and Scintillation Effects Caused by Ionospheric Irregularities.

6. The ELF Field Simulation Program also contains consideration of VLF propagation and consists of the following elements:

- ELF/VLF propagation measurements under quiet and disturbed ionospheric conditions. The disturbance being supplied by relativistic electron precipitation (REP) events and by solar particle events (SPE) at high latitudes.
- Satellite based measurement of precipitating particles and of their effect on the ionosphere. Ultraviolet TV cameras and X-ray detectors will be used to measure absorption in the ionosphere.
- In-situ rocket measurements in the ionosphere
- Incoherent-Scatter radar measurements on the ionosphere
- Satellite-and-ground-based optical measurements

Figure 1 lists these experiments and the experimenters for most.

Figure 2 shows the geometry of the experiments.

The overall program objectives are as follows:

- Utilize natural disturbance phenomena during upcoming solar maximum period (1978 - 1982) to simulate effects of a nuclear burst on ELF/VLF communication links.
- Communicate with existing U.S. Navy experimental ELF link at WTF to receiving sites across the Polar Cap during the disturbances. Also utilize existing VLF transmitters on similar propagation paths.
- Provide a comprehensive definition of the disturbed communication media using satellite, rocket, and ground-based measurements to determine spatial configuration, source characteristics and resulting ionospheric composition as inputs to the communications propagation prediction models.
- Perform a comparative test between predicted signal strength changes and actual measured signal strengths.
- Update the models as necessary to reflect the experimental data.

7. The results obtained from these experiments will be applied directly to the modeling of the U.S. Navy ELF and VLF communication systems under normal and nuclear-disturbed conditions. Existing models at the Naval Ocean Systems Center will be updated based on the knowledge acquired from these experiments. The improved models should result in the design of more efficient, cost effective, reliable communication systems under hostile conditions. The only unresolved problem at this time is assignment of the satellite experiment to a launch vehicle so that it will be in polar orbit in the time frame to coincide with high solar activity.

8. Over the last three years, we have funded a theoretical and experimental effort to develop a holographic radio camera for measurement of ionospheric irregularities and to demonstrate its

capabilities in a field experiment. The research has been performed by Megatek Corporation and by the Naval Ocean Systems Center with the experiment fielded at the NOSC La Posta, California Observatory. The radio camera consists of an array of accurately placed receiving antennas and the accompanying data processing and analysis equipment and algorithms. A known signal from the TRANSIT navigation satellite is received at each of the antennas after being modified in phase and amplitude by passage through the irregular ionosphere. Using these amplitude and phase changes, it is possible to mathematically reconstruct the ionospheric irregularities. The Air Force Geophysical Laboratory is currently considering installation of a holographic radio camera at Goose Bay, Labrador.

9. A new related effort was started this year to determine the correlation of equatorial scintillations with zonule winds at F-region altitudes. Radar and scintillation data taken at Guam is being analyzed.

10. Finally, in the strategic communications area, a new effort will be started in FY 79 in the area of stimulated emission of energetic particles. This will be a correlated ground-based VLF transmitter and satellite based particle detector experiment. The VLF transmitter will propagate a radio wave up the magnetic field lines; these waves should interact with energetic particles in the radiation belts near the equator changing their pitch angle distribution and causing more of them to be absorbed in the atmosphere. The satellite

will measure the increased precipitation of the particles at high latitudes just above the ionosphere. The experimental arrangement is illustrated in Figure 3.

11. Such an effect, if it exists, could have very important implications for radiation belt dumping, selected communication disruption, and satellite survivability.

Tactical Communications and Surveillance Concepts

12. This task is primarily concerned with research in ASW support. It currently consists of the following subtasks:

- Sound detection in optical fibers
- Investigation of Poly (Vinylidene Fluoride) (PVF₂) as an acoustic transducer
- Arctic and marginal ice zone surveillance study
- Aircraft/Submarine communications
 - ULF/ELF magnetic and electric dipole systems
 - Optical fiber submarine to buoy link

13. The application of optical fibers for sound detection was an outgrowth of Field Projects Program research using laser beams to study underwater shock. Optical fiber was used to control dispersion of laser beams. Phase and amplitude changes in the fiber can be used to measure compression wave in the medium. The ONR effort has looked at possible systems for use as loop, single fiber, and beam forming array. NRL, NOSC and NAVSEA are currently investigating conceptual systems also.

14. The basic properties of PVF₂ have been under investigation by the ONR Chemistry Program for sometime. Recently, we have begun

investigating its piezoelectric properties for possible hydrophone application. It is particularly interesting in a towed array application. In previous work, the NOSC has designed and tested individual hydrophones using PVF₂. The current effort will attempt to propose promising line arrays and two-dimensional arrays. The advantages of PVF₂ are given in Table I.

15. The concept under investigation for an optical fiber communication link between a submerged submarine and an active buoy for coordinated ASW activity is shown in Figure 4. The fiber would be of neutral buoyancy and would be laid out from the submarine under minimal tension. Repeaters would be used in the fiber as necessary. Figure 5 gives the attenuation vs. wavelength for currently available corning fibers and for fibers still undergoing experimental test before marketing. Cost of fiber is likely to be the determining factor in when such a system becomes economically feasible.

Diagnostics and Environmental Effects
of Nuclear Explosions on Naval Systems

16. Current objectives of this task are:

- Detection, classification and localization of underwater nuclear explosions
- Avoidance of radiological hazard at sea
- Prediction of surface waves produced by underwater explosions
- Determination of the effects of the Arctic environment on nuclear weapon phenomena

17. A recently completed subtask was the effects of explosively generated water waves on surface effect vehicles (SEV). The objectives were to

TABLE 1

ADVANTAGES OF PVDF PIEZOELECTRIC FILM TRANSDUCERS

1. LOW WATER ABSORPTION
2. EXCELLENT RESISTANCE TO OILS AND MOST CHEMICALS
3. EXCELLENT WEATHERING RESISTANCE
4. GOOD THERMAL STABILITY
5. VERY TOUGH MECHANICALLY
6. LIGHTWEIGHT
7. MECHANICALLY FLEXIBLE
8. HIGHLY SHOCK RESISTANT; RESISTANT TO ROUGH HANDLING AND EXPLOSIVE SHOCK
9. SPECIFIC ACOUSTIC IMPEDANCE MATCHES WELL TO SEA WATER
10. HIGH DIELECTRIC CONSTANT; LOW DIELECTRIC LOSS
11. MADE FROM COMMERCIAL RESIN THAT CAN BE FABRICATED IN ARBITRARY SHAPES AND SIZES
12. EXCELLENT PIEZOELECTRIC RESPONSE FROM D.C. INTO MHz
13. CAPABLE OF BEING FABRICATED INTO DIRECTIONAL RECEIVING ARRAYS

develop an analytical model including the explosion wave environment and a dynamic representation of a typical SEV, and to assess the SEV performance to chosen sets of conditions incorporating yield, standoff distance, and shallow or deep water location. Accomplishments are as follows:

- Development of Comprehensive Computer Code Including:
 - Explosion Wave Environment
 - Large Ship Motions
 - Revised Air Cushion Dynamic Simulation
 - Heave Attenuation Effects
- Cost Effective Code
 - Run Time 1/5 Real Time Simulation
- Vulnerability Studies Include:
 - Deep Water Explosion Wave Simulations Including Variations in:
 - Ship Headings
 - Speeds
 - Yields
 - Standoff Distance
 - Shallow Water Explosion Wave Simulations
 - Sinosoidal Wave Simulations for Code Verification
 - Investigation of Possible Evasive Procedures

18. Current efforts consist of (1) array processing for improved signal to noise ratios in hydrophone arrays; (2) reverberation analysis for single station detection, classification and localization of underwater nuclear explosions; and (3) surface wave generation by

underwater explosions.

Arctic Environmental Effects on
Conventional Weapons Phenomena
and Sensors

19. The broad objective of this task is to determine if conventional weapons and sensors designed for use in temperate zones will operate properly in the Arctic environment. Specific objectives to accomplish this include the following:

- Characterization of weapon and sensor environments in the Arctic
- Comparison with temperate zone environments
- Determination of sensor reactions
- Determination of anomalous weapon phenomena
- Validation of existing system, recommendation of improvements, or recommendation against Arctic use

20. Current effort consists of two subtasks. In the first, the effects of ice cover on acoustic homing sensors is being investigated. Such things as surface capture, ice keel target masking, and noise generation in the marginal ice zone are being investigated. This information is crucial when contemplating use of acoustic homing torpedoes in Arctic ice conditions.

21. The second effort is an Arctic and marginal ice zone naval mining study. The magnetic, acoustic, seismic and hydrostatic anomalies of chosen regions are being investigated to determine which, if any, of the existing mine mechanisms or combinations thereof are suitable for use in each location. The requirements for ice penetration are also being considered for each of the regions under study.

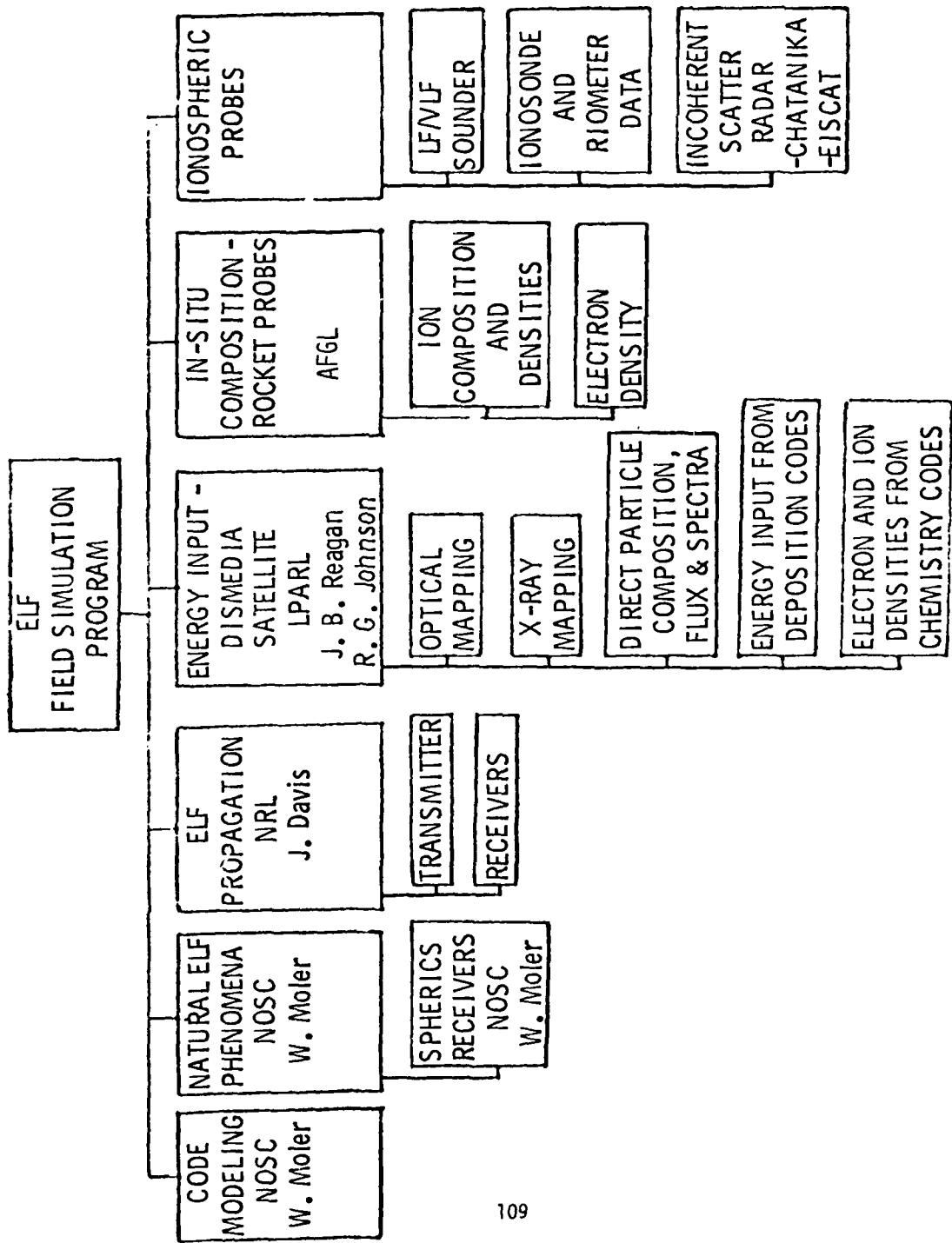


Figure 1

ELF FIELD SIMULATION PROGRAM, CONCEPT DIAGRAM
(DASHED LINE ILLUSTRATES ONE PROPAGATION PATH)

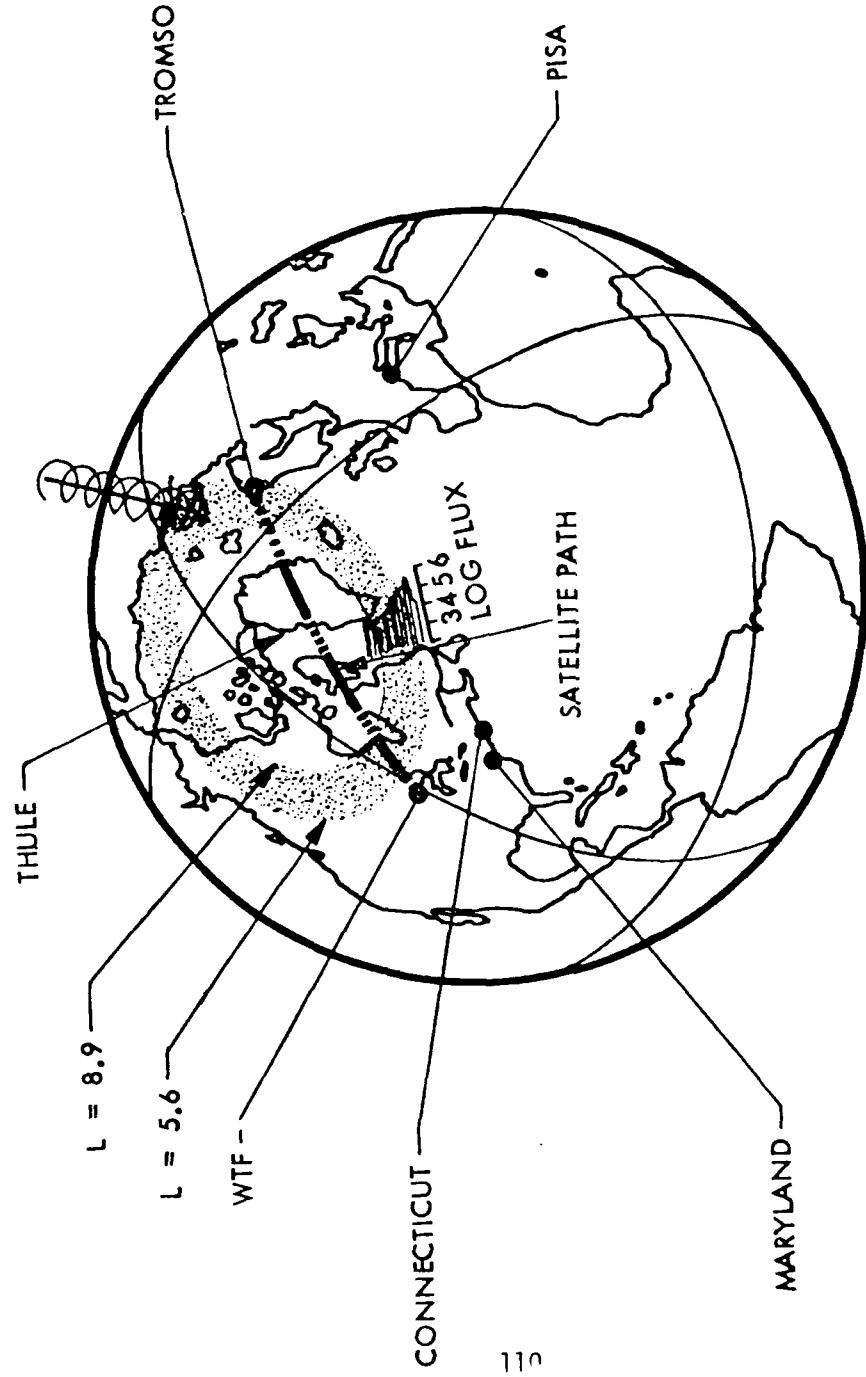


Figure 2

STIMULATED EMISSION OF ENERGETIC PARTICLES (SEEP) EXPERIMENT

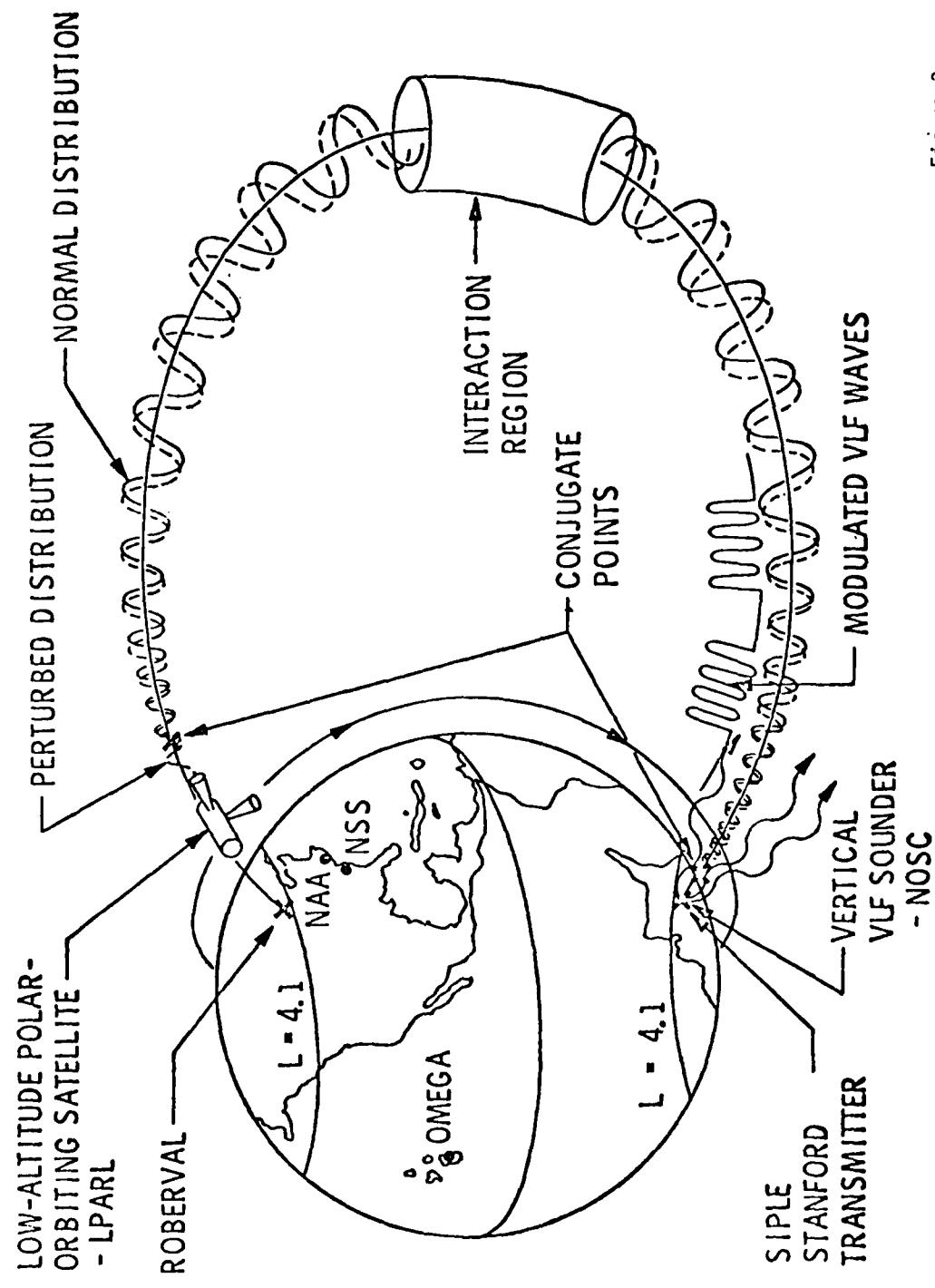


Figure 3

CONCEPTUAL SUBMARINE/AIRCRAFT COMMUNICATIONS LINK

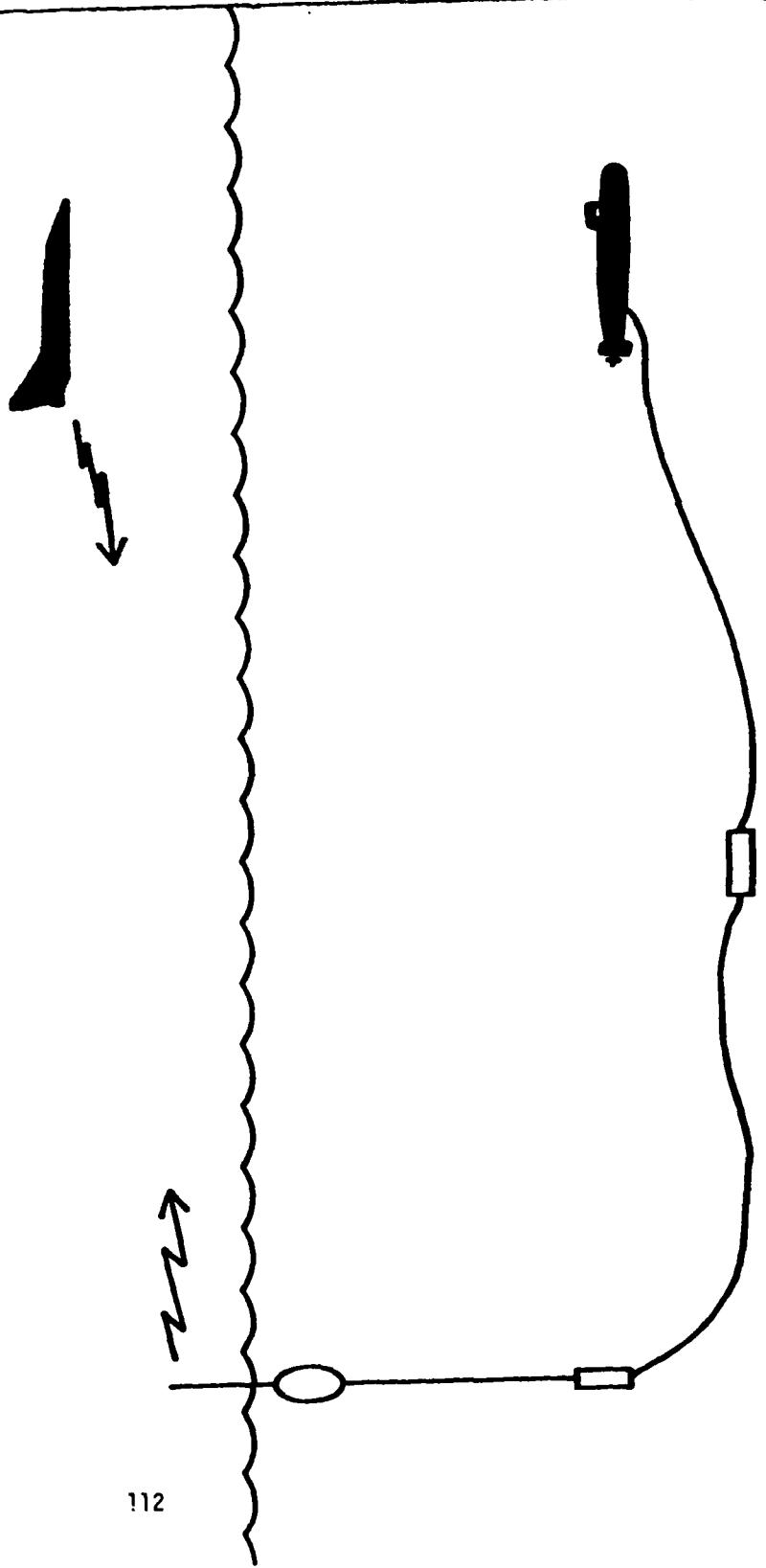
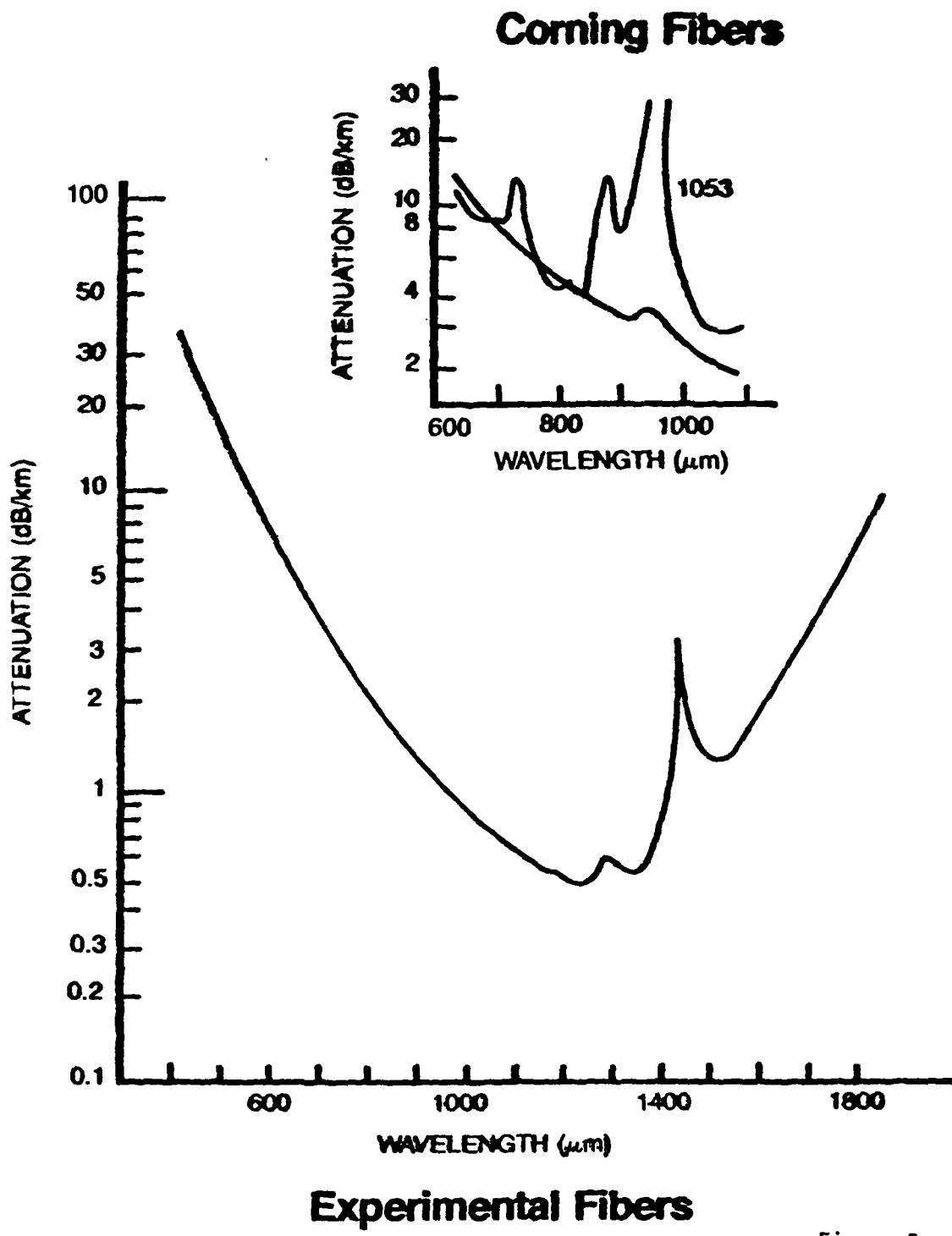


Figure 4

Attenuation In Optical Fibers



EARTH PHYSICS PROGRAM

R.S. ANDREWS, 696-4122
J.G. HEACOCK, 696-4122

ONR CODE 463

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DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
ARLINGTON, VIRGINIA 22217

IN REPLY REFER TO

Earth Physics Program (Code 463) Review

10 March 1978

A. Introduction

1. Code 463 maintains a broad program to retain cognizance of the entire field of earth physics but places a focus for funding on projects having potential for Navy and Marine Corps application.
2. To realize the broad spectrum represented by the subject area of earth physics, several members and former members of our division have handled some of the specific tasks.
 - a. Dr. Forrest Dowling, formerly of the ONR Chicago Branch Office and now a private consultant, has assisted in our hostile artillery location/seismic and geothermal projects.
 - b. Mr. Jake Warner, retired from the Field Projects Program, helped us in the area of shallow water seismic surveillance.
 - c. Commander Jim Minard, USN, is now assigned to Code 460 and will be working part-time on shallow water seismic surveillance. He has previously received a MS degree in Oceanography at the Naval Postgraduate School.

In addition, John Heacock and I have been working together in the Program during much of the past year.

3. Geophysical Monograph 20 of the American Geophysical Union, edited by John Heacock and entitled "The Earth's Crust," has been published. It contains an excellent survey of earth physics in the lithosphere with many articles by ONR Principal Investigators.
4. The field of earth physics has benefited from a number of recent projects and concepts such as we have shown in Figure 1. A few comments should be made about several of the items noted.
 - a. The concept of plate tectonics has evolved into a practical working hypothesis, supported by efforts such as the Deep Sea Drilling Project (DSDP).
 - b. The Vela Uniform program developed methodology, instrumentation, and education in seismology that have found current use in earthquake studies.

c. A "dry DSDP" project is currently being studied as a potential national program. We presently know more about the ocean crust than continental crust from drill hole sampling. The national program on continental seismic reflection profiling will assist in location of deep continental drilling sites, and the drill hole data will feed back to aiding in the interpretation of seismic records.

d. New attention to energy resources has resulted in advances in geophysical signal processing, satellite remote sensing, and intensification in studies of the earth's crust.

5. Figure 2 shows some of the activities in which Code 463 participates to keep current in earth physics programs outside of ONR.

B. General

1. The Earth Physics Program has the basic objective of supporting studies of the physical properties and processes of the solid earth, primarily the lithosphere or upper 100 km, as they impact the operating Navy and Marine Corps. Our budget for FY 78 and estimated budget for FY 79 are shown on Figure 3.

2. The three principal areas of focus by our Program at present are (Figure 4) seismic propagation, earth/ocean tides, and lithospheric studies. Of the three, lithospheric studies provide important input to the two more specific areas.

C. Seismic Propagation

1. Seismic propagation is divided into two projects, hostile weapons location and shallow water surveillance. The Principal Investigators in each of these projects for this year are shown in Figure 5. Under shallow water surveillance, one Investigator at NOSC is working directly on this project with a Navy objective in mind, while the other Investigators are providing environmental data relevant to the project.

2. The objectives of this area are listed in Figure 6. These studies are unique in that they represent attempts to exploit seismic surface wave propagation, along with possible body waves, to locate sources of seismic energy either through mechanical coupling or transfer of acoustic energy into the rigid earth. The ranges of interest are generally less than 100 km, less than typical teleseismic studies. The value of using 3-component geophones as sensors has already been demonstrated in shallow water and on land.

3. Some of the highlights of the hostile weapons location project are itemized in Figure 7. New data processing techniques being applied to seismographs from a 155mm howitzer firing have successfully located the weapon at a range of 5 km and detected the weapon at 11 km. Records collected at a range of 17 km are yet to be analyzed. Various modes of propagation of seismic energy from sources are being exploited for their location potential, and an understanding of the role of the earth as a filter will enhance the development of appropriate location algorithms. A Seismic/Acoustic Passive Surveillance Workshop, sponsored jointly by ONR and the Marine Corps Development Center at Quantico, VA, on 7 and 8 March 1978, brought about 60 investigators together from many military labs and research organizations. A summary of the Workshop, along with reports describing a number of the presentations given, will be distributed in early May 1978. Recommendations have been made to the Director, Marine Corps Development Center, to redirect the exploratory development effort in passive surveillance, and to the Chief of Naval Research to provide additional basic research funds necessary to focus on-going mathematical, statistical, geophysical, and other relevant programs on the Marine Corps' passive surveillance requirements. Coordination of various efforts and opening of communication between investigators were also strongly recommended.

4. Two summaries covering the subject area of shallow water surveillance (Figure 8) have recently been completed. One of these was by Underwater Systems, Inc., under a contract from the Field Projects Program, ONR, and the other was by Bob Urick, Tracor, under support from NRL. The NCSC experiment noted in Figure 8 represents probably one of the best environmentally monitored field tests conducted in this field. Funded and conducted by NCSC off Panama City in 1976, the experiment collected data that has never been analysed. At least a small segment of the data should be studied to determine how this experiment may benefit our program. Code 463 is presently coordinating efforts with NAVELEX for studies being conducted at NOSC.

D. Earth/Ocean Tides

1. The area of earth/ocean tides (Figure 9) presently involves a one-lab project. The objectives of this area (Figure 10) are in harmony with the recognizable deficiency in the present status of ocean tide analysis on a world wide basis (Figure 11).

2. Among the highlights of this project (Figure 12) are the favorable comparisons between tidal gravity inversion predictions in the Northeast Pacific Ocean and bottom pressure measurements. For the M_2 (semi-diurnal lunar) component, this comparison results in agreements in amplitude of 5 cm and in phase of about 5^0 (20 min). At the very

least, 100 deployments at optimal locations of the Geophysical Ocean Bottom Instrument (GOBI) will provide mapping comparable to the careful deployment of 300 bottom pressure sensors, representing a considerable savings in time and cost.

E. Lithospheric Studies

1. The largest area of focus in the Earth Physics Program, lithospheric studies may be tentatively broken into the three sub-areas shown in Figure 13. Our support of geothermal explanation is small, placing an emphasis on studies of basic geophysical methods for geothermal explanation at Navy bases which also have considerable application and interest to civilian projects.

2. In general, the objectives of lithospheric studies (Figure 14) are to support in a broad manner the specific areas discussed previously and to address basic research that we feel has potential future application to the Navy and Marine Corps. Some of the highlights of this area are shown in Figure 15. It should be noted that previous work support by Code 463 has aided in the identification of potential geothermal resources at Navy bases, one of which is Adak, Alaska, presently being drilled, and another, in Oahu, Hawaii, will be drilled in about October 1978. An important activity in this area was a lithospheric Workshop sponsored by ONR and held in Arlington, VA, on 15 and 16 March 1978. This Workshop brought together about 30 military investigators and program managers, along with several ONR Principal Investigators, to discuss current knowledge of the electrical properties of the earth's crust and the potential for lithospheric communication. A summary of this workshop, along with reports from the presentations, will be distributed in early May 1978. An active program of theoretical studies and applied laboratory and field research was recommended in this subject area.

F. Conclusions

1. The Earth Physics Program supports studies of the physical processes and properties of the solid earth, with focus on funding of projects having potential for Navy and Marine Corps applications.

2. As projects develop strong interest and endorsement from labs and systems commands, specific attention will be given with the goal of transferring the technology to exploratory development. This attention will include funding of relevant basic research in the subject area, providing consultant expertise from the basic research community to specific experiments and field tests, and to coordinate diverse efforts concerning the subject to assure continuity, filling of technology gaps, and timely transfer of technology.

3. The Earth Physics Program will retain its broad cognizance of this dynamic area by participation in many coordination activities throughout the relevant government, academic, and professional groups.

EARTH PHYSICS - RECENT EVOLUTION

PLATE TECTONICS
VELA UNIFORM
DEEP SEA DRILLING PROJECT
CONTINENTAL SEISMIC REFLECTION PROFILING
DEEP CONTINENTAL DRILLING
ENERGY NEEDS - GEOPHYSICAL EXPLORATION
FOSSIL FUELS
GEOTHERMAL
SATELLITE REMOTE SENSING
ENVIRONMENTAL IMPACT STUDIES
EARTHQUAKE PREDICTION AND RISK MITIGATION
EXTRATERRESTRIAL "FIELD TRIPS"
ADVANCES IN GEOPHYSICAL SIGNAL PROCESSING

FIGURE 1

EARTH PHYSICS COORDINATION ACTIVITIES

SEISMIC/ACOUSTIC PASSIVE SURVEILLANCE WORKSHOP (WITH MARINE CORPS
DEVELOPMENT CENTER AND ONR CODE 100M)

LITHOSPHERIC ELECTROMAGNETIC PROPERTIES WORKSHOP

INTERGOVERNMENTAL COMMITTEE ON THE SOLID EARTH SCIENCES - PANEL
ON DEEP CONTINENTAL DRILLING (WITH DOE, NAS, NSF, ETC.)

INTERAGENCY GEOPHYSICAL DISCUSSION GROUP (WITH AFOSR, NAS, NSF,
DOE, NASA, DMA, NRC, NOAA, ETC.)

U.S. NATIONAL COMMITTEE ON GEODYNAMICS - NAS

NON-ACOUSTIC ASW WORKING GROUP - ONR

FIGURE 2

EARTH PHYSICS BUDGET

<u>FY 78</u>	<u>FY 79</u>
670K	857K

RR 03201

<u>PRINCIPAL RESEARCH AREAS</u>	<u>CURRENT PROJECTS</u>
SEISMIC PROPAGATION	- - - - - HOSTILE WEAPONS LOCATION
EARTH/OCEAN TIDES	- - - - - SHALLOW WATER SURVEILLANCE
LITHOSPHERIC STUDIES	- - - - - TIDAL GRAVITY INVERSION AND - - - - - GEOID CORRECTIONS
	- - - - - CONTINENTAL CRUSTAL STUDIES
	- - - - - OCEANIC CRUSTAL STUDIES
	- - - - - GEOPHYSICAL TECHNIQUES FOR - - - - - GEOTHERMAL EXPLORATION

FIGURE 4

SEISMIC PROPAGATION

HOSTILE WEAPONS LOCATION (\$97K)

FLETCHER/DORMAN - INSTITUTE FOR ACOUSTICAL RESEARCH

TURPENING - ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN

BOWLING - PRIVATE CONSULTANT

SHALLOW WATER SURVEILLANCE (\$109K)

NORTHROP - NOSC

OLIVER/ISACKS - CORNELL UNIVERSITY

SUTTON - HAWAII INSTITUTE OF GEOPHYSICS

HOOTZ/NAFE - LAMONT DOHERTY GEOLOGICAL OBSERVATORY

LATHAM - UNIVERSITY OF TEXAS, GALVESTON

FIGURE 5

SEISMIC PROPAGATION OBJECTIVES

- STUDY COUPLING, PROPAGATION, AND SENSING OF SEISMIC ENERGY
FROM SOURCES SUCH AS WEAPONS, VEHICLES, AIRCRAFT, AND SUBMARINES.
- DEVELOP ENVIRONMENTAL TRANSFER FUNCTIONS.
- EVALUATE GEOPHONES VS HYDROPHONES (MICROPHONES) IN PASSIVE
SURVEILLANCE ON LAND AND IN SHALLOW WATER.

FIGURE 6

HOSTILE WEAPONS LOCATION HIGHLIGHTS

NEW DATA PROCESSING TECHNIQUES FOR DETECTION AND LOCATION OF
LOW FREQUENCY SEISMIC ENERGY FROM ARTILLERY.

PASSIVE SEISMIC SURVEILLANCE LESS DEPENDENT ON VARYING
ENVIRONMENTAL CONDITIONS THAN ACOUSTIC.

ONR/MCDEC JOINT WORKSHOP ON SEISMIC/AcouSTIC PASSIVE SURVEILLANCE
COORDINATION OF EFFORTS WITH MARINE CORPS, NAVSEA, NOSC, NCSC,
AND MIT LINCOLN LAB FOR NCSC FIELD TEST.

SHALLOW WATER SURVEILLANCE HIGHLIGHTS

RECENT SUMMARIES OF SHALLOW WATER SURVEILLANCE USING GEOPHONES.

ADVANTAGES OF THREE-COMPONENT GEOPHONES OVER VERTICAL GEOPHONES AND HYDROPHONES.

USE OF SONOBOUY WIDE-ANGLE REFLECTION SOLUTIONS TO ATTAIN DISTRIBUTION OF SOUND SPEED AND ATTENUATION WITH DEPTH BENEATH THE SEA FLOOR IN CONTINENTAL SHELF AREA.

NCSC EXPERIMENT.

NOSC FIELD WORK COORDINATED WITH NAVELEX.

FIGURE 8

EARTH/OCEAN TIDES

TIDAL GRAVITY INVERSION AND GEOID CORRECTIONS (\$140K)

KUO - LAMONT DOHERTY GEOLOGICAL OBSERVATORY

EARTH/OCEAN TIDES OBJECTIVES

PROVIDE A UNIQUE MAP OF THE TOTAL OCEAN TIDES WORLDWIDE FROM INVERSION OF TIDAL GRAVIMETRY (LAND, ISLAND, AND OCEAN BOTTOM STATIONS).

USE THE TIDAL MAPPING FOR ANALYSIS OF COASTAL TIDAL HEIGHTS AND CURRENTS (WITH ONR CODE 462) AND SATELLITE GEODETIC STUDIES (WITH ONR CODE 483, DMA, NAVOCEANO, AND NSWC DAHLGREN).

FIGURE 10

TIDAL GRAVITY INVERSION

"...THE ART OF NUMERICAL SOLUTIONS TO THE LAPLACE'S TIDAL EQUATIONS IN SOLVING THE GLOBAL OCEAN TIDES HAS REACHED A PLATEAU. EXTENDED EXPERIMENTAL OCEAN-BOTTOM TIDAL OBSERVATIONS TO PROVIDE THE NECESSARY CONSTRAINTS IN THE SOLUTIONS TO THE LAPLACE'S TIDAL EQUATIONS AND TO THE INVERSION SCHEME ARE MOST URGENTLY NEEDED."

RESOLUTION I
PERMANENT COMMISSION ON
EARTH TIDES - EIGHTH
SYMPOSIUM (1977)

FIGURE 11

TIDAL GRAVITY INVERSION HIGHLIGHTS

THERE IS NO UNIQUE TOTAL OCEAN TIDE MAP AT PRESENT.

GOBI INSTRUMENT PACKAGE (MEASURING OCEAN BOTTOM TIDAL GRAVITY, PRESSURE, CURRENTS, AND TEMPERATURE) READY TO DEPLOY FOR 6-MONTH PERIODS AT OPTIMAL LOCATIONS.

GOBI DEPLOYMENTS - 100; PRESSURE SENSOR DEPLOYMENTS - 300.

ENDORSEMENT OF DMA (WAFER 82 GROUP) AND COORDINATION WITH NAVOCEANO AND NSWC DAHLGREN.

LITHOSPHERIC STUDIES

CONTINENTAL CRUSTAL STUDIES (\$133K)

HOUSLEY - ROCKWELL INTERNATIONAL SCIENCE CENTER
SIMMONS - MASSACHUSETTS INSTITUTE OF TECHNOLOGY
BRAILE - PURDUE UNIVERSITY
KELLER - COLORADO SCHOOL OF MINES

OCEANIC CRUSTAL STUDIES (\$128K)

OLIVER/SACKS - CORNELL UNIVERSITY
SIMMONS - MASSACHUSETTS INSTITUTE OF TECHNOLOGY
COX - SCRIPPS INSTITUTION OF OCEANOGRAPHY
SUTTON - HAWAII INSTITUTE OF GEOPHYSICS
LATHAM - UNIVERSITY OF TEXAS, GALVESTON
CHRISTENSEN - UNIVERSITY OF WASHINGTON
ENGDAHL - U.S. GEOLOGICAL SURVEY

GEOPHYSICAL TECHNIQUES FOR GEOTHERMAL EXPLORATION (\$22K)

KELLER - COLORADO SCHOOL OF MINES
LESHACK - DEVELOPMENT AND RESOURCES TRANSPORTATION COMPANY

FIGURE 13

LITHOSPHERIC STUDIES OBJECTIVES

DETERMINE RELATIONSHIPS AMONG PHYSICAL PROPERTIES OF THE LITHOSPHERE,
AND INFER SUCH PROPERTIES AT DEPTH FROM GEOPHYSICAL MEASUREMENTS.

SUPPORT BASIC RESEARCH TO PROVIDE LITHOSPHERIC PARAMETERS REQUIRED
FOR SURVEILLANCE, COMMUNICATIONS, WEAPON DELIVERY, NATURAL HAZARD
PREDICTION, AND ENERGY RESOURCE ASSESSMENT.

MAINTAIN CLOSE CONTACT BETWEEN CIVILIAN EARTH PHYSICS RESEARCH AND
MILITARY REQUIREMENTS.

FIGURE 14

LITHOSPHERIC STUDIES HIGHLIGHTS

EXCITATION OF SEISMIC ENERGY FROM SUBDUCTION ZONE TECTONICS AND PROPAGATION TO CONTINENTAL SHELF CRUST AND INTO THE OCEAN.

GEOHERMAL EXPLORATION AT NAVAL INSTALLATIONS.

LABORATORY AND FIELD MEASUREMENTS OF SEISMIC AND ELECTRICAL PROPERTIES OF THE CRUST (CONTINENTAL AND OCEANIC).

LITHOSPHERIC WORKSHOP.

GEOGRAPHY PROGRAMS
EUROPEAN ACTIVITIES

H. DOLEZALEK, 696-4025
ONR CODE 462

If we want to create and maintain a sufficient degree of preparedness for the case of a conventional war, we must concentrate our ability to assess and predict one of the basic military decision factors, that of the environment, on the danger areas of the world. Europe is such an area (figure 1). Coastal and shallow-water conditions are different in many ways from those found on our shores. At the same time, the native research situation there calls for cooperation, but the defense aspect is still undeveloped. Our partners in cooperation will be mostly civilians and civilian institutions, just as it is in the United States. Cooperation is being established both bilaterally and multilaterally. Based on our experience in former contacts, we expect to obtain much new knowledge.

One way to obtain such cooperation is by inviting interest in existing political and scientific institutions, both international ones and national ones.

Within NATO, we have contact with several bodies (figure 2). Within its military structure, official negotiations have been established with both Panel I and Panel III of the Defence Research Group. Within NATO's civilian side, our contacts are with the Science Committee and its Air-Sea Interaction Panel.

Under Panel I, a Long-Term Scientific Study with the title "Long-Term Prospects for the Prediction of Coastal Conditions for Military

Operations" has been negotiated in due course and established (figure 3). Its so-called Multinational Exercise will take place in September on an island in the North Sea. Nine countries and several NATO agencies are involved. The study will be based on six military scenarios in the European Area, that is six types of military coastal or shallow-water operations taking place at various types of coast typical for Europe (figures 4 and 5). Then, the environmental processes will be investigated as to the state of art, expected development and recommendations for related research. The outcome is expected to be a document which declares in detail the interest of NATO in this type of research. On this basis, further cooperation will then be initiated.

We have already begun to generate interest in such cooperation by asking the civilian NATO Science Committee to look into the feasibility of having a shallow-water oceanographic experiment which includes all-weather maritime remote sensing in the North Sea area (figure 6). Such an experiment, called MARSEN, has then been launched by a leading scientist in Europe, Professor Hasselmann (figure 7). It is scheduled for the fall of 1979 and in the present stage of planning involves about thirty-five groups from eight countries. The area of the Experiment is the South Eastern North Sea (figure 8) with ground based stations on various islands such as Sylt ($54^{\circ}45'$ to $55^{\circ}3'$ N and $8^{\circ}15'$ to $8^{\circ}25'$ E), Helgoland ($54^{\circ}10'$ N and $7^{\circ}55'$ E), and Norderney ($53^{\circ}40'$ N and $7^{\circ}10'$ to $7^{\circ}20'$ E), research platforms such as the Nordsee Tower ($54^{\circ}43'$ N and $7^{\circ}10'$ E) in 30 m of water, 80 km from the nearest shore, equipped with living quarters and laboratories and a permanent crew, and the Noordwijk Tower

(about $52^{\circ}8'$ N and $4^{\circ}10'$ E) in 20 meters of water, about 10 kilometers from the Dutch coast; similarly equipped and a variety of other surface truth stations. There will be, in addition, boats and buoys and aircraft and the satellites overhead.

ONR is not involved in this experiment in any direct way, but we intend to support individual researchers if they come with a good proposal. We hope, however, to benefit from it (figure 9) in improved capabilities and scientific knowledge in remote sensing and shallow-water oceanography.

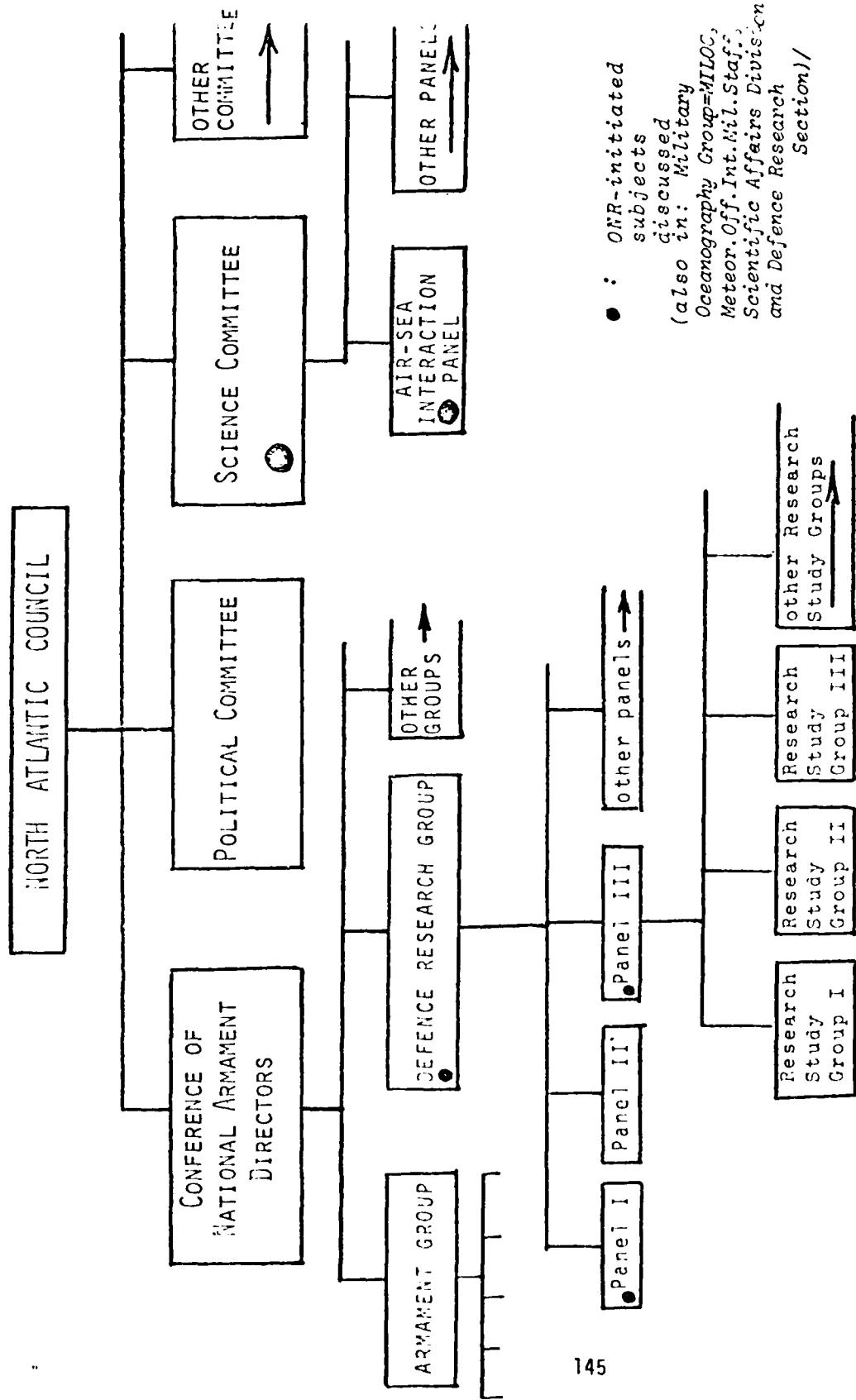
Future Satellites

Of our various bilateral interests with individual European nations, I want only to mention that a multitude of Norwegian institutions and scientists with whom we established contacts during our NATO efforts, has approached us and other US agencies to obtain cooperation in their NORSEX 1979 Experiment (figure 10). The Coastal Current Project within NORSEX is interested in frontal mixing processes so typical for the Norwegian Coastal Region, and it will apply a large variety of methods.

These are some of the main efforts under way now (figure 11), but there are, of course, always occurring additional cooperative discussions, activities and exchanges in much greater number than I could present to you here.

WHY EUROPE?

- EUROPE IS AN IMPORTANT AREA FOR THE UNITED STATES.
- COASTAL RESEARCH IN EUROPE HAS BEEN CONDUCTED SINCE LONG FOR CIVILIAN PURPOSES, BUT DEFENSE APPLICATIONS ARE NOT WELL ADVANCED AND THERE IS NO COORDINATED EFFORT.
- THE MOST COST-EFFECTIVE AND POLITICALLY MOST PRUDENT MANNER FOR THE US TO HAVE A CAPABILITY IN THIS FIELD AND AREA IS THE DEVELOPMENT OF A CO-OPERATIVE EFFORT WITH INDIVIDUAL COUNTRIES AS WELL AS WITH N A T O. THIS WILL ALSO STIMULATE OWN EFFORTS BY THE EUROPEANS.
- IN THE COURSE OF THIS EFFORT, WE EXPECT SCIENTIFIC AND TECHNICAL GAPS TO BE IDENTIFIED AND PRIORITIES OT BE ESTABLISHED. IN THE LONG RUN, WE EXPECT MUCH NEW KNOWLEDGE TO RESULT, CLOSELY TIED TO THE NEEDS OF THE UNITED STATES AND ITS ALLIES IN EUROPE.
- SCIENTIFIC EXPERTISE, RELATIVELY AMPLE GOVERNMENT FUNDING, LONG EXPERIENCE ESPECIALLY IN COASTAL ENGINEERING, LARGE AMOUNTS OF DATA AND EXCELLENT RESEARCH FACILITIES ARE AVAILABLE IN EUROPE OR ARE DEVELOPING NOW.



NATO - DEFENSE RESEARCH GROUP - PANEL I

Long-Term Scientific Study: LONG-TERM PROSPECTS FOR THE PREDICTION OF
COASTAL CONDITIONS FOR MILITARY OPERATIONS

Suggested to Panel I : 25 November 1975

Accepted by Panel I : 5 November 1976

Accepted by Defence Research Group: March 1977

Prospectus accepted by Panel I : 10 May 1977

Study Director assigned: 10 May 1977 DR. PETER C. BADGEY

Working Paper distributed: March 1978

"Multinational Exercise" scheduled for : 4 - 17 September 1978

at LIST on the German North-Sea island of SYLT

"Points of contact have been established by:
NATO HEADQUARTERS
AND SEVERAL NATO
ORGANIZATIONS
NORWAY
DENMARK
GERMANY
NETHERLAND
BELGIUM
FRANCE
UNITED KINGDOM
UNITED STATES
Interest has been expressed by
ITALY

Figure 3

LONG-TERM SCIENTIFIC STUDY ON THE COASTAL ENVIRONMENT

ORGANIZATION OF THE STUDY:

1. Six or more "military" Working Groups determine requirements

starting from six "SCENARIOS": AMPHIBIOUS OPERATION AT JUTLAND (1)
DEFENSIVE MINE FIELDS IN WESTERN MEDITERRANEAN (2)
MINE COUNTERMEASURES FROM BORDEAUX TO ROTTERDAM (3)
COMMANDO ACTION AT CHALKIDIKE PENINSULAS (4)
COASTAL DEFENSE NORTHERN NORWAY (5)
ANTI-SABOTAGE IN NORTH SEA AND DUTCH COAST (6)
but also considering other types of European coasts for similar operations

2. Three "scientific" Working Groups and maybe subgroups discuss scientific potential and expected development for support of operations

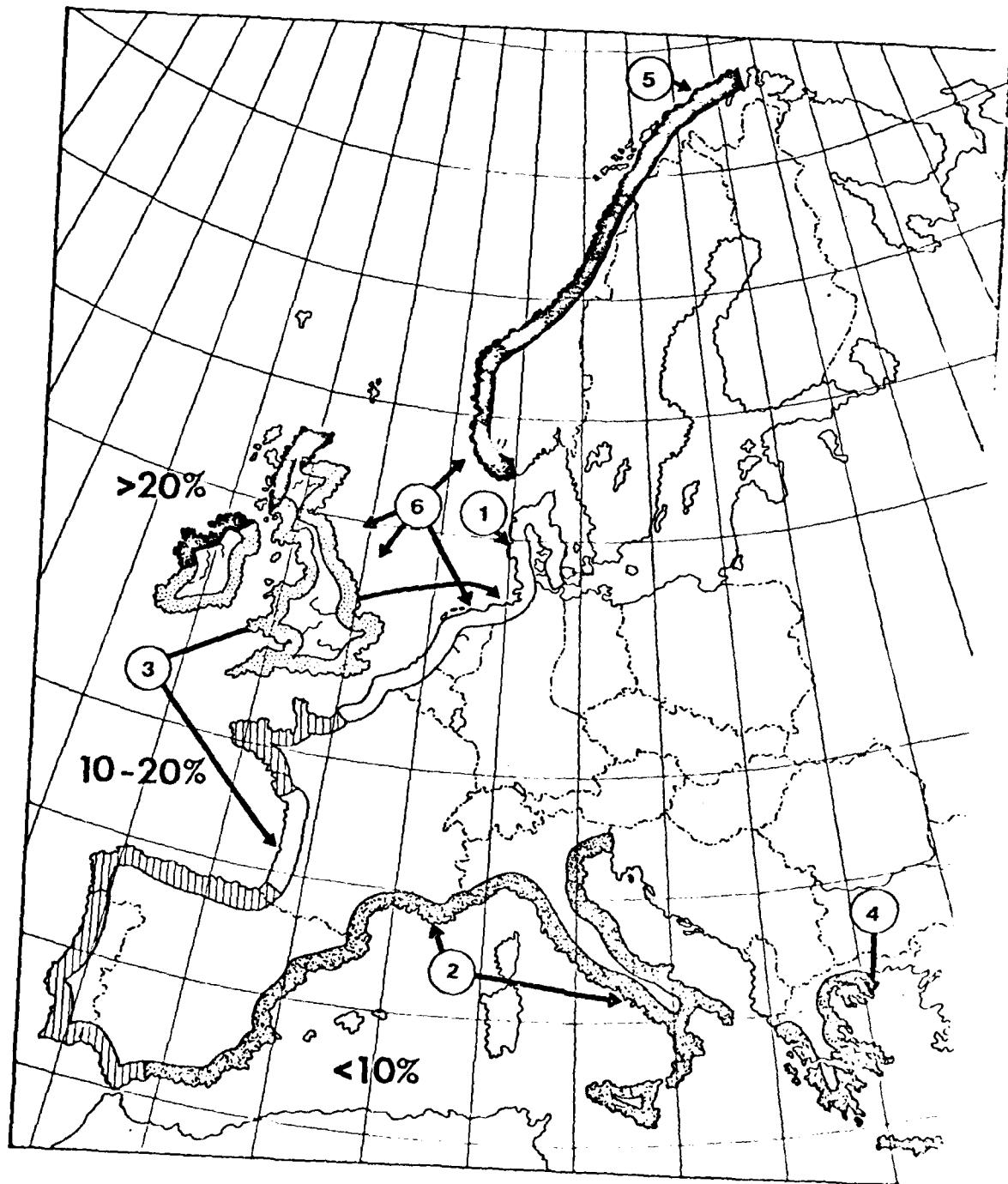
starting from discussions of three domains: STORM PROCESSES (Transient Synoptic Weather Systems)
SEA PROCESSES (Shallow-Water Hydrodynamics)
LAND RESPONSES (Bottom and Shore Features)

3. Several "technological" Working Groups consider certain problems and techniques such as :

- COASTAL INFORMATION REFERRAL SYSTEMS
- MARITIME REMOTE SENSING
- DATA PROCESSING
- NUMERICAL MODELS
- SOME POINTS OF SHALLOW-WATER ACOUSTICS

4. Editorial Party writes the FINAL REPORT

Figure 4



NATO SCIENCE COMMITTEE
and its Air-Sea Interaction Panel

NATO DEFENCE RESEARCH
GROUP / PANEL III

NATO MILOC
"Military Oceanography Group"

INTEREST IN MARITIME REMOTE SENSING (MARSSEN)

Presentation to A/S Interact. Panel:

25 March 1977

149

First Presentation to Science Cttee:

3/4 June 1977

Discussions with A/S Interact. Panel:
19-21 September 1977

First Meeting of MARSSEN Groups:
13 - 15 December 1977

Second Meeting of MARSSEN I Group:
6 March 1978

Discussion by Panel III:
January 1978

7-8 Apr 78

M A R S E N I * (NORTH SEA 1979 EXPERIMENT)

A Coastal-Geographic and Shallow-Water Oceanographic Experiment

Methods: Satellite Remote Sensing, Aircraft Remote Sensing,
Ships, Buoys, Research Platforms in the North Sea,
Stations on Islands and on the Shore

Time: 15 August -- 15 September 1979: OCEAN FRONTS, THERMALS
15 September--15 October 1979: STORMS, WAVE INTERACTIONS

Chairman and Participants: DR. KLAUS HASSELMANN *Max-Planck Institut
für Meteorologie, Hamburg*

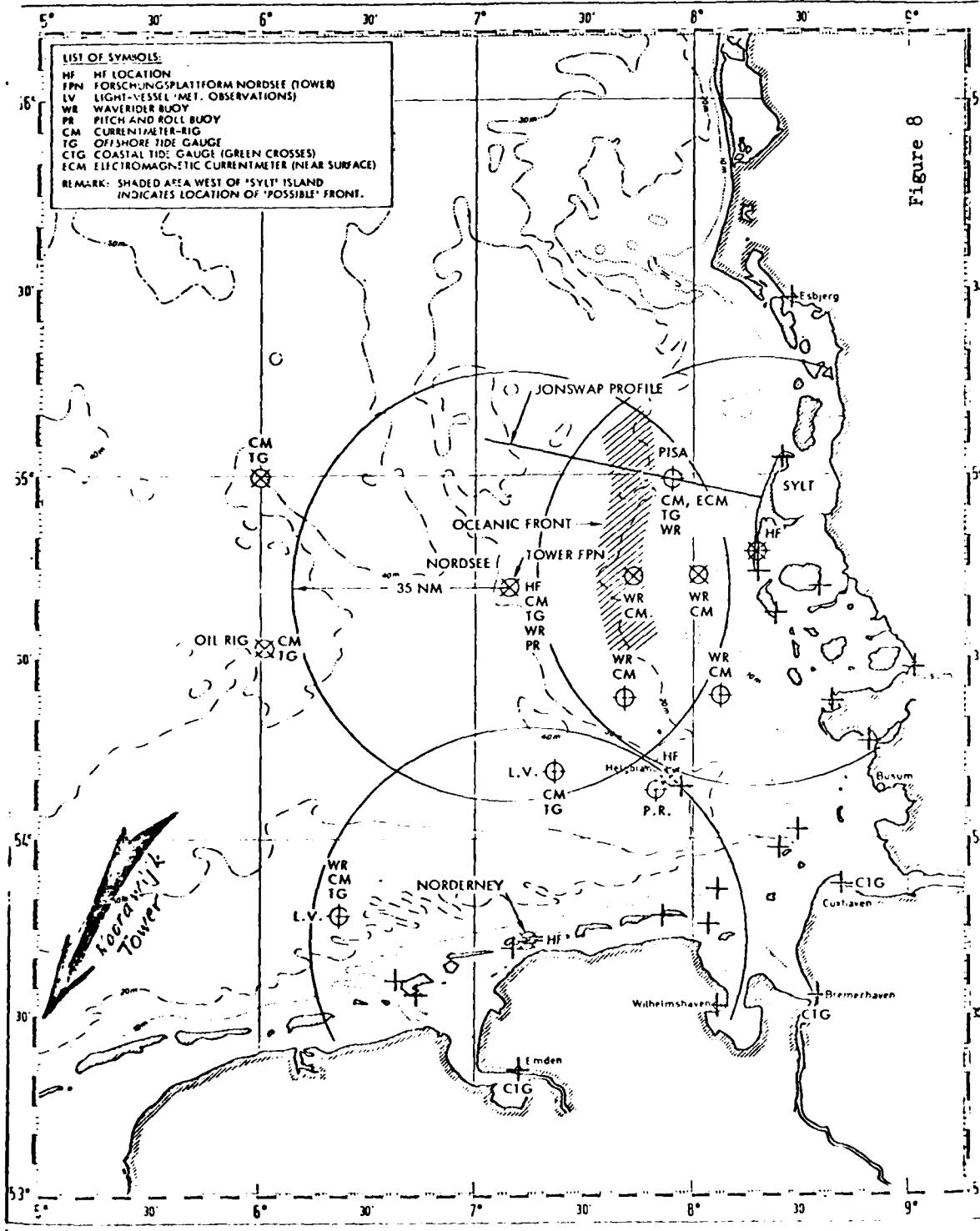
MORE THAN THIRTY GROUPS FROM EIGHT COUNTRIES:
Denmark, Germany, Netherlands, Belgium
France, United Kingdom, Canada, U.S.A.

Place: South-Eastern North Sea with German Bight and Part of English Channel

* Maritime Remote Sensing

Figure 7

Figure 8



ONR INTEREST IN MAREN I :

- Develop all-weather capability for remote sensing of shallow-water and coastal parameters from satellites and aircraft
- Improve understanding of shallow-water oceanography and coastal geography in the NORTH SEA AREA which is of large military interest and has some unique environmental and oceanographic features
- Test research results of ONR contractors in this field
- Obtain knowledge on improvements needed for future SEASAT satellites
- Help to promote European interest and expertise in order to initiate their future participation in research towards our and their common goals
- Establish a working relationship with European scientists in general

N O R S E X * 1 9 7 9 ---- COASTAL CURRENT PROJECT **

Scientific Aims: Study of:

1. Frontal Processes, Waves - Eddies
Biological Processes
2. Mixing Processes: Fjords - Coastal
Water - Atlantic Water
3. Time and Space Variability of
Surface Currents and -Waves
4. Meteorological Effects
Upwelling, Fjord Inflow
5. Internal Waves

Main Experiment Area:

A Rectangle 5 degrees of longitude wide' and
one degree of latitude high near Bergen

LEADERSHIP AND PARTICIPATION:

M. MORK
R. SAETRE
J. STRØMME

Principal Investigator
University of Bergen

Ten Norwegian Institutes in NORSEX

American Associates at the Present Time: OSCAR HUH, ROBERT A. SHUCHMAN

* Norwegian Sea Experiment

** One out of three NORSEX Projects

S U R V E Y O N O N R C O D E 460 R E S E A R C H A C T I V I T I E S I N T H E E U R O P E A N A R E A 1978

COASTAL GEOGRAPHY AND SHALLOW-WATER OCEANOGRAPHY IN WEST-, NORTH- AND CENTRAL EUROPE

● Reasons for work in the European Area, see special slide

● Activities Underway now:

--- WITH N A T O (MULTINATIONAL):

Long-Term Scientific Study (Coastal Environmental Prediction)

Exploratory Group on military aspects of remote sensing over oceans and coasts
(possibly leading to a RESEARCH STUDY GROUP ON MARITIME REMOTE SENSING
within Panel III of NATO Defence Research Group)

MARSEN I Experiment already under development, Experiment Plan-Test Report written March 1978
(about eight nations, twenty-five institutions, North Sea, Fall 1979)

--- WITH INDIVIDUAL NATIONS (BILATERAL):

NORSEX (Norwegian Sea Experiment) Spring and Fall 1979, Coastal Current, Oceanic Fronts, etc.

Data Exchange Agreement on Coastal Geography and Shallow-Water Oceanography with Ministry of
Defense of Federal Republic of Germany (now being negotiated)

● Principal Contacts

N A T O Defence Research Group and Defence Research Section
(Panels I and III)

N A T O Science Committee and Scientific Affairs Division
(in particular: Air=Sea Interaction Panel)

N A T O MILOC = Military Oceanography Group

N O R W A Y : several institutes, in particular University at Bergen, and Christian Michelson Inst..

G E R M A N Y : Ministry of Defense, Bonn, Division RÜFo3; Office for Defense Geophysics, Traben-Trarbach;
Defense Research Institute on Underwater Sound and Geophysics, Kiel

Figure 11

RESEARCH & DEVELOPMENT PLANNING SUMMARIES

RESEARCH AND DEVELOPMENT PLANNING SUMMARY		I. AGENCY ACCESSION DN 623343	II. DATE OF SUMMARY MAY 1977	REPORT CONTROL SYMBOL
KIND OF SUMMARY Change JUNE 1976	LEVEL OF SUMMARY Project	B. SUMMARY SECUR.lev Unclassified	C. REGADING GROUP NA	D. WORK SECURITY Unclassified
III. PASTORAL ELEMENT/PROJECT/TASK AREA NUMBER 61153N RR 032-05		IV. FORMER PROGRAM ELEMENT/PROJECT/TASK AREA NUMBER		
L. TITLE (Procede with Security Classification Code) (U) Arctic Research				
15. RESPONSIBLE DOD ORGANIZATION NAME Office of Naval Research ADDRESS Arlington, Virginia 22217		II. START DATE JAN 1951	16. COMPLETION DATE N/A	
16. RESP. IND. Mr. R. K. McGREGOR TELEPHONE NO (202) 692-4118		17. RESOURCES ESTIMATE CURRENT FY 77 BUDGET FY 78 BUDGET II 79	18. BUDGET FUND\$ (Thousands) 3750 4240 4878	19. % OF FUNDS ON CONTRACT/GRANT PROGRAMS 100 100 100
18. PARTICIPATION N/A		20. MISSION OBJECTIVE STO: PN CC MW SL AW OS		
21. SCIENTIFIC/TECHNICAL AREA 000100 Acoustics; 005900 Environmental Biology 012800 Physical Oceanography; 015300 Snow, Ice, and Permafrost				

17. (U) Objective and Approach. To provide knowledge of the spatial and temporal variations of the dynamic environmental processes which occur in the Arctic Ocean and marginal ice-covered seas. Such knowledge together with predictive equations based on fundamental physical theories when given to operational agencies will allow forecasts of the following phenomena: weather, ice drift, ice thickness distribution, acoustic propagation loss, ambient noise, volume reverberation, stability of permafrost, coastal erosion, ocean dynamics and bottom sediment characteristics. Man's performance in cold environment is also investigated; however, emphasis is on physical environment of the ice-covered ocean. Field experiments which gather data are compared to models developed from basic theory. The field work is supported by the Naval Arctic Research Laboratory, Barrow, Alaska which establishes the required camps on drifting ice, coasts or inland and utilizes such bases as Nord and Alert as required. The entire research program is relevant to submarine, surface effects vehicle and aircraft operations; placement of shore/offshore installations; communications; surveillance; weapons development to search and rescue, and remote sensing.

18. (U) Plans. To continue the basic program which includes: sea ice physics, energy exchange processes, acoustic propagation, ice production and drift, oceanography, geophysics, meteorology, coastal processes and cold climate physiology. Acoustic energy transmission continues to be important but the focus is shifting toward an understanding of the character and variability of the medium (water, ice, sea floor). Numerical modeling (ice, ocean) validation and remote sensing will continue. Collection and analysis of ambient noise phenomenon in the Arctic Ocean ice pack and marginal ice zone commenced in MAR 75 will continue. Scientific program shifting toward eastern Arctic. Investigation of East Greenland current to commence. Technology transfer via the N.P. School to the fleet will accelerate. An acoustic reverberation experiment is planned in the Canadian Basin.

19. (U) Progress and Accomplishments. Architectural and engineering studies for conversion of BURTON ISLAND have been completed. Established a chair in Arctic marine sciences at the N.P. School. Aeromagnetic surveys of the Arctic and delineation of the geophysical fabric continue. Determined that sea ice is a highly permeable medium for gases. Samples of the Arctic haze layer confirm that it is dust from the Asian deserts. AIDJEX data have permitted description of the lateral variation of oceanographic features over a full year in the Beaufort Seas. A cooperative under ice program with a British submarine and Canadian plane was successfully executed to determine relationships between top and bottom side roughness. A greatly improved numerical model has been developed to predict the distribution and characteristics of sea ice and is currently undergoing validation at Fleet Weather Facility, Suitland. Another model has been developed to predict the growth and temperature field of undeformed sea ice. Acoustic stratigraphy of Canada Basin will be completed this year.

N3 069-000 A. RESEARCH AND DEVELOPMENT PLANNING SUMMARY		1. AGENCY ACCESSION DN 623542	2. DATE OF SUMMARY June 1977	REPORT CONTROL SYMBOL
3. FUTURE ELEMENT Ch-NEE June 1976	4. LEVEL OF SUMMARY PROJECT	5. SUMMARY SECURITY UNCLASSIFIED	6. REGRADING GROUP N/A	7. WORK SECURITY SECRET
8. FUTURE ELEMENT-PROJECT/TASK AREA NUMBER 61153N RR032-08		9. FORMER PROGRAM ELEMENT-PROJECT/TASK AREA NUMBER		
10. TITLE (Proceeds with Security Classification Code)				
(U) ENVIRONMENTAL FACTORS				
11. RESPONSIBLE/LEAD ORGANIZATION NAME Office of Naval Research ADDRESS Department of the Navy Arlington, VA 22217 RESP IND Joiner, R.G. TELEPHONE NO (202) 692-4204		12. START DATE JULY 1960	13. COMPLETION DATE N/A	
		14. RESOURCES ESTIMATE CURRENT FY 77	15. DOT & E FUNDS (Thousands) 78	16. % OF FUNDS ON CONTRACT/GRANT PROGRAMS 100
		BUDGET FY 78	435	\$100
		BUDGET II 79	500	100
17. PARTICIPATION ARPA, DNA,		18. MISSION OBJECTIVE STO-CC, SB		
19. SCIENTIFIC/TECHNICAL AREA 004900 Defense; 017000 Wave Propagation; 00200 Acoustic; 011400 Nuclear Warfare; 005500 Electricity and Magnetism;				

17. (UNCLASSIFIED) Objective and Approach. Environmental factors and their effects on Naval operations which must exist in their presence are researched. The objective is to provide quantitative descriptions of these phenomena and of their collective influence upon the effectiveness of naval operations. This knowledge will allow navy planners to evaluate alternative naval responses to anticipated conflicts. Phenomena such as underwater explosion effects, acoustic signals, seismic signals, airblast, ground shock, electromagnetic radiation, nuclear particles and thermal radiation are studied. Applications include prediction of damage to ships, aircraft and fixed installations from nuclear explosions; surveillance of clandestine nuclear explosions; diagnostics of nuclear bursts; prediction of effects of electromagnetic pulse (EMP) from high altitude nuclear explosions on aircraft, ships and shore installations.

18. (UNCLASSIFIED) Plans FY-78. Emphasis will continue on naval system vulnerability to nuclear burst effects. Investigation of the optical detection of sound and of the detection and classification of underwater nuclear explosions by instruments on a single ship will be continued. Demonstrate feasibility of sound detection by optical fiber sensor system. Complete study of effects of explosion generated waves on Surface Effect Ships. Theoretically determine feasibility of sub to aircraft communication at ULF in tactical situations. Plans FY-79. Investigate the effects of the arctic environment on nuclear weapons phenomena and on their operational use. Plan test of ULF submarine/aircraft communications. Continue investigation of single point detection of underwater nuclear explosions by reverberation analysis. Continue studies of vulnerability to nuclear bursts of new naval platforms, new systems, and systems in new strategic or tactical situations.

19. (UNCLASSIFIED) Progress and Accomplishments. Feasibility of holographic radio camera demonstrated. Correlation of ELF fading with precipitating energetic particles shown. Investigation of pre-attack alternatives to ELF communications to FBM submarines completed. Aircraft to submarine communication in tactical situation at ULF theoretically determined. Fiber optic detection of hydroacoustic signals demonstrated. Dynamic sizing of hydrophone arrays shown to effect improvement.

388-000 RESEARCH AND DEVELOPMENT PLANNING SUMMARY			1. AGENCY ACCESSION DN 623378	2. DATE OF SUMMARY Jun 77	4. REPORT CONTROL BY JUL SECRET
3. KIND OF SUMMARY Change	4. LEVEL OF SUMMARY Jun 76	5. SUMMARY SECURITY Unclassified	6. REGRADING GROUP N/A	7. WORK SECURITY SECRET	
8. PROGRAM ELEMENT/PROJECT/TASK AREA NUMBER 61153N RR032-04		9. FORMER PROGRAM ELEMENT/PROJECT/TASK AREA NUMBER			
10. TITLE (Provide with Security Classification Code) (U) Geography					
11. RESPONSIBLE DOD ORGANIZATION NAME: Office of Naval Research ADDRESS: Arlington, Virginia 22217 12. REEF IND: Bailey, James S., Dr. TELEPHONE NO: 202-692-4025			13. START DATE Jun 1952	14. COMPLETION DATE N/A	
			15. RESOURCES ESTIMATE CURRENT FY 77	16. DOD & R FUNDS (Thousands) 1,586	17. % OF FUNDS ON CONTRACT/GRANT PROGRAM 100
			BUDGET FY 78	1,890	100
			BUDGET II 79	2,174	100
18. PARTICIPATION NASA, NOAA, DMA, NAVOCEANO, NAVFAC 19. SCIENTIFIC/TECHNICAL AREA 007000 Geography; 005200 Dynamic Oceanography			18. MISSION OBJECTIVE STD - AW OS MC-INT-1		

17. (Unclassified) Objective and Approach. Adequate physical environmental data must be available for all geographic areas in which naval and Marine Corps operations might take place. Knowledge of coastal environments and processes must be increased continually so accurate descriptions and predictions can be made. Reliable environmental data must be acquired rapidly by improved field survey or remote sensing methods; and new techniques are needed to assure that the full information content of imagery and survey data is quickly and accurately interpreted, analyzed, stored, and displayed in useful forms. Information obtained from field, theoretical, and laboratory studies is used by the Navy and Marine Corps in planning and conducting amphibious, shallow water, riverine and charting operations, mine placement and detection, surveillance and reconnaissance; and in weapon selection, target identification and deployment of forces.

18. (Unclassified) Plans. Emphasis will be on interdisciplinary studies of hydrodynamic, atmospheric, and morphological parameters of nearshore and inner shelf coastal environments, identifying significant physical processes, relating the processes and their rates of change to total energy regimes, defining the important properties that must be monitored, and correlating these properties with their expression on remote sensing records. Coastal data management efforts will focus on linkage methods between remote sensors and data banks and on techniques of data compaction and display.

19. (Unclassified) Progress and Accomplishments. Much progress has been made in prediction of current fields in coastal and shallow shelf regions. In areas near latitude 30°N, where inertial currents have the same period as the diurnal tide, it has been found that strong inertial currents result from atmospheric forcing rather than from resonance with the tide and such currents are easily modeled. Studies around islands have shown the presence of clockwise currents of unknown origin around certain islands; the resulting distortion of the gross current field around islands has been shown to follow a simple analytical model. Important new understandings have been gained of the response of shallow shelf waters to intrusive cold air masses; the time and space scales of this response have been extensively measured in a major experiment off the north western coast of Florida. Research in the nearshore zone has shown that whereas edge waves are often an important factor in determining nearshore sediment transport and bar formation/migration, edge waves are of no importance in high wave energy coastal areas. A prototype coastal information system has been incorporated into the Ships Analysis and Retrieved Program of the Navy Ship Research and Development Center, allowing Navy users to quickly locate many available sources of physical parameter measurements and information for a wide selection of coastal regions. The feasibility of using Raman spectroscopy techniques for the remote measurement of three dimensional temperature and density fields in coastal waters has been shown.

1. RESEARCH AND DEVELOPMENT PLANNING SUMMARY		1. AGENCY ACCESSION DN 623376	2. DATE OF SUMMARY June 77	REPORT CONTROL SYMBOL
3. KIND OF SUMMARY Change June 76	4. LEVEL OF SUMMARY Project	5. SUMMARY SECURITY Unclassified	6. REGRADING GROUP N/A	7. WORK SECURITY Unclassified
8. PROGRAM ELEMENT/PROJECT/TASK AREA NUMBER 61153N RR 032-01		9. FORMER PROGRAM ELEMENT/PROJECT/TASK AREA NUMBER		
10. TITLE (Please use Security Classification Code) (U) Earth Physics				
11. RESPONSIBLE DOD ORGANIZATION NAME Office of Naval Research ADDRESS Arlington, Virginia 22217		11. START DATE Jul 1946	12. COMPLETION DATE N/A	
13. RESOURCES ESTIMATE CURRENT FY 77 BUDGET FY 78 BUDGET '79		14. DOD & E FUNDS (Thousands) 497 595 685	15. % OF FUNDS ON CONTRACT/GRANT PROGRAMS 100 100 100	
16. PARTICIPATION DARPA; NOAA; USGS; NOS		17. MISSION OBJECTIVE STO: SB, SH, AW, TW, OS MC INS-1		
18. SCIENTIFIC/TECHNICAL AREA 015200 Seismology; 007100 Geology and Mineralogy; 00690 Geodesy				

17. (Unclassified) Objective and Approach. To solve naval problems created by the earth (e.g. earthquake risk at naval bases); to predict earth behavior important for naval operations (e.g., tides; rotational rate as it influences navigation and guidance); to meet naval needs by using earth resources and properties (e.g., geothermal energy; seismic or electrical propagation characteristics); and to use the earth as part of new operational systems by developing an intimate understanding of the behavior of physical fields in earth materials.

18. (Unclassified) Plans. To study crustal properties in both the field and laboratory; to develop an ability to predict deep ocean and coastal tides without the need for tide gauges; to evaluate geothermal resources for naval use; to provide an improved knowledge of the earth's gravitational shape and rotational behavior; to develop an improved understanding of crustal properties and conditions (e.g., porosity, fluid content, temperature, strength, stress, lithology), and to study the electrical and seismic characteristics of the crust as a propagation medium applicable to communication and the detection and location of hostile weapons or vehicles.

19. (Unclassified) Progress and Accomplishments. New and sophisticated software is under development for the location of hostile artillery by seismic means to evaluate the potential of this method; a new technique has been developed to evaluate the amplitude and distribution of sea state and waves at sea; considerable progress is being made in the evaluation of earthquake mechanisms in the vicinity of the active Aleutian Trench and subduction zone; a new potential geothermal resource center has been located in the Koolau caldera on the island of Oahu, Hawaii; a 500 page Monograph on "The Earth's Crust" (Its Nature and Physical Properties), sponsored and edited by Code 463, will be published in August, 1977 by the American Geophysical Union; and progress is being made in evaluating the physical characteristics of the earth's crust for various operational purposes.

APPENDICES

REFERENCES

1. N. Untersteiner, K. L. Hunkins, and B. M. Buck, "Arctic Science: Current Knowledge and Future Thrusts", Science, Technology and the Modern Navy, ONR-37, 278-297 (1976).
2. O. K. Huh and V. E. Noble, "Remote Sensing of the Environment: Achievements and Prognosis", Science, Technology and the Modern Navy, ONR-37, 299-323 (1976).
3. J. M. Coleman and S. P. Murray, "Coastal Sciences: Recent Advances and Future Outlook", Science, Technology and the Modern Navy, ONR-37, 347-370 (1976).
4. O. G. Villard, Jr., "Radio Wave Propagation in the Solar-Terrestrial Environment: Perspectives for the Future", Science, Technology and the Modern Navy, ONR-37, 265-276 (1976).
5. J. G. Heacock, J. E. Oliver, G. V. Keller, and G. Simmons, "Solid Earth Properties and Their Importance to the Navy: Current Knowledge and Future Prospects", Science, Technology and the Modern Navy, ONR-37, 326-345 (1976).

